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# IN-KNEE: ITS RELATION TO RICKETS,

ETC.

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# MEDICAL AND SURGICAL ASPECTS

OF

# IN-KNEE (GENU-VALGUM):

ITS RELATION TO

# RICKETS,

ITS

PREVENTION AND ITS TREATMENT WITH AND WITHOUT

SURGICAL OPERATION.

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# IN-KNEE: ITS RELATION TO RICKETS,

ETC.

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CORRIGENDUM.—On page 26, line 12 from above, *for* fig. 3 *read* fig. 4.

## "*PRINCIPIIS OBSTA.*"

We have placed at the head of our remarks an oft-quoted maxim, because we hope we shall have convincingly shown in the succeeding pages that the distortion of which we have treated, though one of the most serious, when looked at either as a mere unsightly deformity or as an affection which, in its advanced stage, renders the act of independent walking impossible, is one which is completely preventible by the commonest care of the medical man and parent.

The occurrence of in-knee and out-knee has been long known, but its etiology, pathology and morbid anatomy had not been described until the publication of our lectures on deformities in the 'Lancet,' in 1843-4.

Nevertheless the records of general hospitals show that during the last few years many hundreds of cases of in-knee had attained to so great deformity and inutility that surgeons have thought themselves obliged to have recourse to violent methods of cure, or to a serious "operation," for its relief, although others, as well as ourselves, had never met with a case that did not recover by the help of instrumental means alone. We dare not say that in all the cases in which

osteotomy has been performed the operation was unnecessary. We do, however, affirm that, from the descriptions of many cases which we have read, the operation was in a large number of cases unnecessary, and that in all the distortion should have been arrested in the earlier stage.

We have therefore considered it needful in the following pages to sift the writings, within our reach, of subsequent writers, in search of facts illustrative of the symptoms, pathology, morbid anatomy and treatment of the distortion, with which we have interwoven our experience of the last four decades. From these sources we believe that the result of our labours will shed fresh light upon the knowledge of the distortion, its nature, its prevention, and remedy. The work has been a labour of love, for it has supplied us with clearer views of several problems in regard to this and other deformities, and has raised our esteem and regard for several of those whose names we have quoted, who have been simultaneously working in the same direction. Nor have we spurned recourse to some writers of the last century, who have treated of some of the subjects we have touched upon, for as Huxley says:*—"The growth of Science is now so prodigiously rapid that those who are actively engaged in keeping up with the present have much ado to find time to look at the past, and even grow into the habit of neglecting it. But natural as this result may be, it is none the less detrimental. The

* Address at the meeting of the British Association for the Advancement of Science at Belfast, 1874: 'Fortnightly Review.'

intellect loses, for there is assuredly no more effectual method of clearing up one's own mind on any subject than by talking it over, so to speak, with men of real power and grasp, who have considered it from a totally different point of view."

Many surgeons have based their treatment upon the unfounded belief that considerable enlargement of the internal condyle existed; others, that curvature and enlargement of the internal and lower part of the diaphysis of the femur is the most marked feature of the distortion. The following pages will, we believe, prove that deficiency of the external condylar parts of the femur and of the opposite articular surface of the tibia demand the most consideration, whatever be the method of treatment employed.

In the body of this work, writing from memory, we have stated that, when first writing on the subject of atonic infantile and adolescent in-knee, we had considered it to arise always from rickets. We find, however, that so long ago as in our lectures in the 'Lancet,' 1843-4, we stated* our view of atonic or idiopathic in-knee in the following words:—"When in children, from imperfect nutrition or assimilation, the muscular and ligamentous tissues are weak, and particularly if this weakness of ligament and muscle be associated with stoutness, the articulations of the lower extremities, especially, become deformed, producing the affections known by the names genu-valgum (in-knee) and talipes-valgus spurius (flat-foot), which an appropriate treatment promptly

* Little: 'On Deformities,' p. 23.

relieves." We have shown (p. 9) that Harrison, writing in 1827, recognised the influence of weakness of the fibrous structures in the production of in-knee and spinal curvature.

Our thanks are due to Mr. T. Sulman, draughtsman and artist, for the accuracy and skill which he has devoted to several new and original engravings which illustrate the work.

London, May, 1882.

# IN-KNEE DISTORTION.

## ON IN-KNEE OR KNOCK-KNEE (GENU-VALGUM), AND ITS VARIETIES.

THE term knock-knee is very appropriate in the plural number, but is often inapplicable when one knee only is slightly affected, for in that case it is not constant that the affected knee knocks its fellow. The term in-knee well expresses the nature of the affection. The Germans sometimes call it the X-knee, from the crossing of the limbs in severe cases, but this designation is also inappropriate when a single knee is affected, and because crossed-legs distortion may arise independently of genu-valgum.*

By genu-valgum, in-knee, should be understood a distortion of the *knee joint*, and should be distinguished from a

FIG. 1.

* See annexed figure from Little on 'Deformities,' 1853, p. 174, fig. 74, showing an uncommon form of crossed-legs caused by long forced retention of thighs in a crossed position through sloughing over the hips. This distortion has been popularly called "scissor-legs."

deformity similar in appearance, which mainly depends upon curvature and changes in form of the femur and tibia.

Many writers have treated of the distortion under two forms: (1) the *statical*, in which the influence of gravity has been paramount in its production; and (2) the *rachitic*, in which softening of bones has been the primary disturbing cause. It is, however, obvious that when rachitic softening has taken place, and the sufferer endeavours to assume the erect posture and to effect locomotion in that posture, statical influence will come into operation as well in the rachitic form as in that denominated statical, *par excellence*.

It is desired in this section to draw fully the attention of surgeons to the fact that genu-valgum is an alteration in the form and relation of parts of the knee joint which is apt to accompany several, indeed the majority, of disordered states to which the knee joint is liable, either in their early or in their later stages.

We lay it down as an axiom that in any disorder or disease of the knee structures, active or passive, through which either the relations of parts or the equilibrating forces are disturbed, the condition or distortion termed genu-valgum to a greater or less extent will arise unless interfered with by art.

Hence it may be said that there are almost as many clinical varieties of genu-valgum as there are knee affections, and further that the distortion may arise even in a perfectly healthy knee, when owing to disorder in one limb the sound one is over-laden and over-worked.

In-knee may exist at birth; it may originate in the one-year-old fast-growing infant from the want of mother's milk, from improper and from too watery a diet, without rachitis; it may depend upon unequivocal rachitis, upon infantile paralysis and spasm. It arises (without rachitis) less frequently in the later years of childhood, when the child has been debilitated by measles, hooping-cough, or

scarlet fever, and has been permitted during convalescence to resort too soon to standing or prolonged exertion. On the approach of puberty in both sexes during another fast-growing period, say from the twelfth to the sixteenth year, or later, liability to the distortion again sets in. At any period before adult age the occurrence of white swelling (strumous synovitis) is apt to present, besides contraction of the joint in the flexed position, manifest inward inclination of the knee with corresponding eversion of the leg (genu contractum et valgoideum). With advancing years the rheumatic knee, especially in subjects who were regarded as strumous in their youth, besides becoming contracted in the flexed position, is apt to assume a distinctly valgoid direction, with marked pain in the neighbourhood of the internal lateral ligament and internal condyle, especially when attempts to use the limb are made, and the tendency to distortion is not checked by art.

The author has seen several cases of considerable genu-valgum in tall, robust adolescents, and adults affected with undue stoutness (polysarcia), inordinate height and weight having apparently contributed to the distortion.

This frequent liability to the complaint under so many conditions does not spring, as often asserted, from the natural form and relation of the component parts of the limb, and especially of the articulating surfaces of the knee joint, for in the normal state, a well-knit knee, the active and passive structures, the moving and resisting powers, are so well balanced that the most perfect symmetry and a large reserve of capability for use beyond the average use exists.

It can no more be admitted of genu-valgum than of congenital club-foot, as has been stated by some surgeons, that every child born into the world has a certain degree of, or a certain tendency to, both those affections. All that can be admitted is that when disorder or disease of the

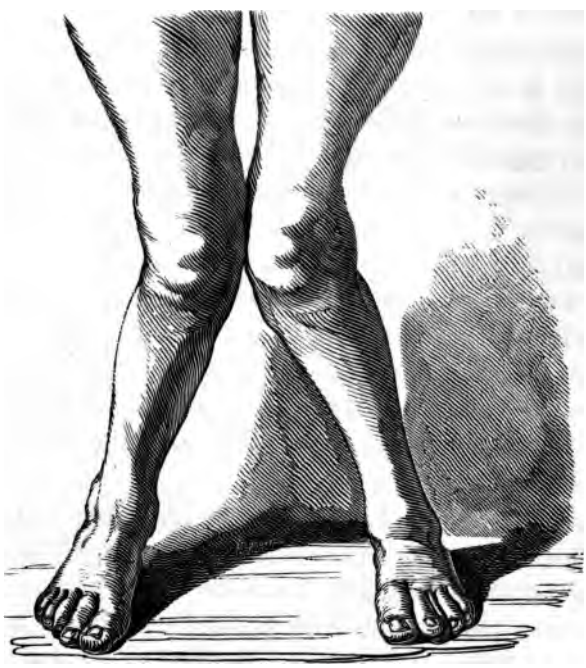
knee or foot takes place and distortion ensues, the form of the distortion will be determined in a certain direction, rather than in other directions, by the natural anatomical relations and functions.

In the causation of genu-valgum the natural greater size of the internal condyle, the naturally adducted position of the femur in relation to the trunk and to the tibia, the asserted naturally less developed condition of the external articular suface of the tibia, the known greater physiological range of the abduction of the tibia over adduction in some positions of the knee, cannot be regarded as primary causes.

We equally deny the primary influence of contraction of any muscle, *e. g.* the biceps femoris, in producing the distortion, except where its origin has been spasm.

The annexed woodcut figures of tolerably severe adole-

FIG. 2.



*Moderate knock-knee, non-rachitic.*

scent genu-valgum will convey to the uninformed reader a better idea of the distortion than words. It consists of undue inversion of the thighs to the extent that the knees may touch (fig. 2) or overlap one another (fig. 3); the

FIG. 3.

*Severe atonic neglected knock-knee, arrived at the adolescent stage.*

legs are more or less widely abducted as regards the thighs, and consequently are separated. In extreme cases the particular change of relation of the thigh and legs is so considerable that the limb may entirely cross, sometimes to the extent that the right foot presents where the left should do, and *vice versâ*. As the distortion augments, the individual when attempting locomotion sinks from the upright posture, so that considerable bending of knees

becomes apparent. This bending of the knees diminishes the deformity. The disappearance of the deformity on full bending the knee is a characteristic symptom even of genu-valgum in the severest forms. In the earlier stages excessive extension of the knee (hyper-extension to 10 or 15 degrees) may also be present.

It will be observed further, in fig. 4, that not only marked abduction of the legs has taken place, but that the

Fig. 4.

*Rachitic in-knee during childhood. In this drawing one foot inclines to varus, the other to valgus.*

tibias are rotated outwards on their perpendicular axes. The distortion, consisting of knee inversion, leg abduction, and outward rotation, is greater in the left than in the right limb. The internal condyles may be felt and seen to be unduly prominent; that of the left leg, which has been passed in front of the right, is strongly marked in the drawing. The external condyle is concealed in the characteristic hollow or angle, which obtains in genu-valgum on

the external aspect of the knee. Observers differ as to the state of the ankle in knock-knee, some stating it to be affected with valgus, others that it has a tendency to varus. It would be more exact to say that sometimes the foot exhibits more or less valgoid tendency, at other times a varoid tendency. As a rule, in young children, the inner ankle will be found to have more or less sunk, and the point of the foot to be proportionately turned out; in older patients the foot, owing to the efforts of the patient to ease the ankle when walking, may assume the reverse position. Even young children, who are brought for consultation by parents because "they turn their toes in," when seated, are found on examination to have incipient knock-knee and flat-foot (spurious valgus). The gait is in all stages unsteady and unsightly; in advanced cases the upright attitude is impossible, and walking is effected with bent knees; sometimes attempts at locomotion are quite given up. The individual is then obliged to confine himself to sedentary pursuits; the resulting want of exercise leaves the limbs to the further disturbing influence of the unused thigh muscles, which results in aggravation of the original deformity. In-knee is not only a very frequent distortion, but, as already stated, one which is induced by primary causes of very dissimilar characters.

H. Mayer,* Volkmann,† C. Hueter,‡ and Mikulicz,§ describe two forms of the complaint: that from softening of bones—the *rachitic*; and that which arises from undue

* H. Mayer: 'Die Osteotomie; Illustrirte Medicinische Zeitung.' July, 1852.

† Volkmann: 'Handbuch der Allgemeinen und speciellen Chirurgie,' von Pitha und Bilroth, Erlangen, 1872.

‡ C. Hueter: 'Klinik der Gelenkkrankheiten mit Einschluss der Orthopädie,' 1876.

§ Mikulicz: 'Archiv für Klinische Chirurgie,' von Dr. B. von Langenbeck, vol. xxi., 1879.

augmentation of the work which the knee joint has to perform when bearing the weight of the trunk, and especially when carrying heavy loads—the idiopathic, or *statical* form. They mostly regard the rachitic form as originating in childhood, and the statical that which originates in adolescence. Volkmann coincides with our views, that idiopathic or statical in-knee occurs in infants beginning to walk; and in adolescents, Volkmann says between the ages of two and four years, and between fourteen and seventeen. It will be seen further on, that we have frequently met with the idiopathic or atonic form during the first year of infant life.

Many observers have described congenital knock-knee; and C. Hueter, *op. cit.*, p. 263, refers to "a kind of traumatic form," caused by accidental dislocation of the epiphysis of the tibia in early childhood.

Our experience enables us to affirm with confidence that the distortion may originate under several other very different predisposing conditions, all operating to add valgoid knee, though not an equal degree of it, to the pre-existing or co-existing disorder or contraction.

Congenital genu-valgum is rare and slight in amount, and is commonly rachitic; sometimes it is due to the same cause which produces co-existent congenital varus, *viz.*, convulsive muscular contraction (rétraction musculaire of Guérin). Gravity, in its ordinary sense, cannot affect the fœtus in the same manner that it influences the fast-growing infant trying to stand and walk. The rachitic fœtal limbs, however, if not modifiable in utero by gravity, are probably sometimes susceptible of external influences, *e. g.*, pressure through the uterine walls of the neighbouring maternal organs, and the action of their own muscles.

The following is the arrangement of the non-congenital clinical varieties of genu-valgum we have adopted:—

*a.* Atonic, idiopathic, statical or uncomplicated genu-

valgum, not rachitic, in infants hand-fed upon improper and too watery diet before or when beginning to walk.

*b.* As in older, strong-limbed children who had for one or more years walked perfectly well until they became affected with general debility followed by genu-valgum, as a sequela of scarlet, gastric, and other fevers; too early return to the use of the limbs in such persons having engendered weak or in-knees, sometimes accompanied with other distortions caused by premature use of trunk and limbs, such as scoliosis and flat-foot. See fig. 5.

FIG. 5.

*Atonic or idiopathic in-knee, from debility on resuming exercise too soon after acute illness, not rachitic. From Harrison, on 'Spinal Diseases,' London,* 1827.

*c.* As in adolescents, not rachitic, suffering from general debility caused by too rapid growth, late hours, too much

standing, and too much carrying of heavy weights, as in pursuing particular mechanical occupations, often aggravated amongst the very poor by insufficient feeding.

*d.* As in children congenitally weak, with congenital heart, vascular and capillary disease (cyanosis), or lung disease (atalectasis); rarely from non-congenital heart disease.

*e.* From over-use of a sound knee, or from a previously sound knee having accommodated itself to a short opposite, or to a weak, wasted neighbour.

*f.* As in over-fed, over-stout, fat, heavy infants; over-stout and over-tall adolescents.

In addition to these varieties of genu-valgum, as deduced from difference of origin, all, however, being alike in the circumstance that the genu-valgum—the morbid inward inclination of the knee—is the only knee joint affection, there is a series of knee distortions in which inward inclination—a genu-valgoid direction—of the joint is an important and striking element, though not the more important part of the disorder. They might be termed sub-forms of genu-valgum, and those forms *a* to *f*, already defined, in which the inward inclination of the knee constitutes the whole of the deformity, might be termed true or genuine in-knee; and those in which the genu-valgum is the minor part of the affection might be termed false or spurious in-knee. This denomination of cases would correspond with the manner in which we speak of true or complete (meaning bony) ankylosis, and false or spurious (meaning fibrous) ankylosis; or as we speak of true talipes valgus (meaning congenital or complete) and spurious talipes valgus (meaning rachitic talipes valgus, or flat-foot).

*g.* For convenience sake here we will drop the expression sub-form, and speak of the next variety as the paralytic or spastic one, arising from partial paralysis or spasm of the muscles moving the knee joint. These cases, except as to

the disordered innervation, are closely allied to the former varieties *a* to *f*.

*h*. From rachitis. It will be hereafter shown that in this form curvature of the thigh and leg bones plays as important a part in the deformity as the articular knee structures, if not a more important part.

*i*. From rheumatic, strumous and traumatic knee affections. In synovitis, whether rheumatic, strumous, or the effect of accident, the often long-continued distention of the joint and the impairment of joint structures immediately due to the congestion or inflammation, are the causes of weakness, and relaxation of the connection of the bones with each other, upon which is apt to follow contraction in the bent position, sub-luxation,* and a genu-valgoid form of the joint with abduction of the tibia.

It will now be seen that each of these primary causes of in-knee, except *e*, which results from "accommodation," which is an example of the complaint having been produced by a cause acting outside of the affected limb, operate by lessening the tone or strength of some or all of the active and passive structures of the joint itself,—the muscles, the ligaments, and the bones. The secondary or determining causes are, as will be seen, the form and bearing of the articular surfaces of the femur and tibia upon each other, and the action of gravity, &c., of the weight of the head, upper extremities and trunk upon the enfeebled and loosened joint, modified in the case of rickets by the peculiar form acquired by the thigh and leg bones in severe rachitic instances of this deformity.

From this enumeration of the clinical and pathological varieties of in-knee it will be understood why neither con-

* The important and mischievous part performed by sub-luxation of the tibia in knee joint diseases was, it is believed, first pointed out by the author. See lectures on "Contractions and Deformities" in the 'Lancet,' 1842—3; and also in 'Treatise on Ankylosis,' London, 1843.

currence with the views of those recent authors who divide the cases into two forms (the rachitic and statical), or with C. Hueter, who adds a third form (the traumatic), nor still less with those who see in the distortion of in-knee a single form (that of rachitic origin), can be arrived at. When in-knee is looked at from an etiological and constitutional point of view, it will be evident that all cases, including the rachitic ones, might equally be called statical; that in all, the weight of the body being attempted to be inefficiently borne by the limb causes the passive structures to yield beneath its influence.

The principal conclusions at which we have arrived in this section are that there are several clinically and pathologically well-marked varieties of in-knee, and that of these varieties the rachitic is not the most frequent.

---

## OUTWARD CURVATURE OF KNEE.

Cases of an opposite form of distortion of the knee, see fig. 6, termed outward yielding or curvature of it (genu-extrorsum*), are occasionally met with, mainly in rachitic subjects. It is much less frequent than genu-valgum, or inward inclination. The greater frequency of the latter is apparently due to the natural inward direction of the shaft of the femur and condyles.

The immediate or mechanical cause of outward knee inclination has not been satisfactorily explained. It is commonly of rickety origin, and is combined with curvature of the femur and tibia. When one knee is inclined inwards and the other outwards, the latter appears as if it were the result of accommodation. It may also occur independently of rickets, as when one limb is shortened from paralysis,

* We were the first to name and describe genu-extrorsum curvatum at the Royal Orthopædic Hospital in 1839.

knee disease, or accident, the other limb yielding outwards for accommodation purposes.

The annexed figure exhibits a case of considerable outward curvature of doubtful origin. There exists obvious curvature of all the long bones of both lower extremities, but they are disproportionately long, the reverse of the shortened limbs of a rickety subject. The individual had not the head and face of rachitis, nor were other signs of former rickets present. He had a puny chest and lanky legs, common to the ill-fed fast-growing atonic cases of distortion (such as genu-valgum atonicum), and may have followed an avocation which had predisposed to distortion. It is well known, for example, that jockeys are apt to become bow-legged. As the lower extremities are comparatively long compared with the trunk, it is probable that the over-growth and the curvature took place during the most active period of growth, from about the age of twelve or thirteen to sixteen or seventeen.

FIG. 6.

*Double outward curvature of lower extremities.*

The disproportion is so unusually great as to suggest the idea that it was due to excess in growth (deformity from excess), with proportionate weakness and liability to yield to gravity, and to any undue retention of the limbs in a particular position.

## PATHOLOGY AND MORBID ANATOMY OF IN-KNEE, AND ITS VARIETIES.

We have already stated (pp. 2, 11) that every disordered condition of the structures composing and surrounding the knee joint, the integrity of which is necessary for the due performance of its functions, may give rise more or less completely to knock-knee.

The essential first evil consequence of disordered action is a weakening of the naturally strong connection which exists between the femur and tibia. If the weakening affect the ligaments the joint is at the mercy of the muscles, the stronger ones asserting their supremacy; and if the individual is able to attempt to stand or walk the influence of gravity becomes irresistible, the joint yields to it, constituting displacement or distortion. If the primary evil be in the muscles it will consist of either augmented power (spasm) or diminished power (paralysis), or a modification of that less considered and less completely defined property known as *tone*.

We have shown that from disordered, or probably rather from insufficient nutrition of tissues, both ligaments and muscles suffer from diminished tone and strength, and that genu-valgum arises more often from loss of tone than from any other single cause. Nevertheless pathologists, when treating of this distortion and of distortions in general, except as regards scoliosis, miscalled lateral curvature, have seldom taken atony of fibrous and muscular structures into account. The popular term weakness has taken its place.

Atonic genu-valgum is related to several other disorders in which weakness of fibrous structure (including muscular weakness, short of paralysis) exists, *e.g.*, prolapsus ani, prolapsus uteri, ectropium senile, hernia, flat-foot, &c. Those complaints which depend upon muscular weakness (atony) have more attracted the notice of pathologists than those in which weakness of ligaments plays the more important part.* This oversight as to the important part played by atony of fibrous structures and muscles is partly due to the positive material tendency of pathology during the last four or five decades. That which is apt to be recovered from does not afford material for the scalpel or microscope (without resort to the *emporte-pièce*, a proceeding little to be commended and rarely employed). We do not despair that, attention being drawn to the subject of atony of fibrous and muscular structures, more will hereafter be known respecting its essential nature.

Gravity usually tells unfavourably against atonic structures; consequently in the case of atonic distortions the ankle joint suffers most from this cause (flat-foot), next the knee (genu-valgum), next the hip (certain waddling gait, when not caused by rickety change in the neck of femur), lastly, the spinal column (scoliosis).

As an instance of imperfect gait from want of tone of parts, we may cite the hobbledehoy movement of a fast-growing adolescent boy, one who has "outgrown his strength," the power of co-ordinating his muscles (apart from a possible touch of chorea) has been outdone by the over-rapid elongation of the bones of the lower extremities proper to this period of life. We have occasionally been consulted as to adolescent girls in whom, as in the above class of boys, we could discover no distinct disease, yet the

* Consult Louis F. Stromeyer: Platt-fuss 'Beiträge zur Operativen Orthopædik,' Hanover, 1838. Ernst Stromeyer: 'Ueber Atonie fibröser Gewebe,' Wurzburg, 1840.

gait was extremely wanting in steadiness and firmness, sometimes amounting in the minds of the attendants to lameness of hip. It is a question in some such cases of want of tone in the ligaments and muscles attached to the rapidly enlarging pelvis, analogous to the hobbledehoy gait caused by rapid elongation of the bones of the boy's lower extremities. We have elsewhere stated that we have known even a girl grow six inches in a year, just before puberty. The case was one of incipient scoliosis. We had periodically measured her during the year, as an aid in determining the probability of cure.

Hitherto it has not been sufficiently noted that there are two periods in the age of man at which growth is extraordinarily rapid. The first period is from birth until the age of nine months; the second period is at the approach of, or during, puberty or adolescence, say from the tenth or twelfth to the fourteenth or sixteenth year, more or less.

We are indebted to Burdach* and Schwartz for precise details on this interesting head. Schwartz watched a child which grew in the

| | | |
|---|---|---|
| First week . . . | 1½ in. | |
| ,, month . . . | 2 ,, | 3 lines.† |
| Second ,, . . . | 1 ,, | 1 line. |
| Third ,, . . . | 0 ,, | 7 lines. |
| Fourth ,, . . . | 0 ,, | 11 ,, |
| Fifth ,, . . . | 0 ,, | 6 ,, |
| Sixth ,, . . . | 0 ,, | 7 ,, |
| Seventh ,, . . . | 1 ,, | |
| Eighth and ninth month | 1½ ,, | |

* Carl F. Burdach: 1830, 'Die Physiologie als Erfahrungswissenschaft,' 3 Band, p. 236.

† We were led to enquire into this subject through having repeatedly observed how very often in the treatment of congenital varus in infants during "the month" it became necessary to exchange the splints used for longer ones.

so that its length increased in nine months about one-third, say 8½ German inches.*

The average rate of growth in the infant is estimated to be 6 to 8 German inches during the first nine months, or from 18 or 20 inches to 24 or 26 inches. Burdach says that growth is during the

| | |
|---|---|
| Second year . . . . . | 3 in. |
| Third ,, . . . . . | 2 ,, |
| Fourth ,, . . . . . | 2 ,, |
| Fifth ,, . . . . . | 2 ,, |
| Sixth ,, . . . . . | 1 ,, |
| Seventh ,, . . . . . | 1 ,, |

at which period there is often a stop. If in the first seven years the length has increased 20 or 22 inches, it will increase in the second seven years only 10 or 12 inches, and attains in the male 5½ feet. The weight which at seven yēars is 37 lbs. German, increases at the age of fourteen 22 or 25 lbs.

Adolescence extends from puberty to completion of growth, *i. e.*, until sixteenth to twenty-third year in the male, and fourteenth to twentieth in the female. Growth at the beginning of this period proceeds rapidly, and, especially in cases where it had not greatly advanced, makes a fresh start. During adolescence the growth is from 10 to 12 inches. We believe that in the male growth may not stop until the age of twenty-five. It is known that ossification is not completed before thirty. It was stated at the meeting, in 1881, of the British Association for the Advancement of Science, that growth continues until the age of forty; probably in width only.

These two periods of most rapid growth are, we venture to say, predetermined physiologically: the first to hasten

* German inch $= \frac{128}{135} = 9519$ English. German pound $= \frac{56}{51} =$ 1·098 English.

of the external condyle and enlargement of the internal condyle co-exist. In our opinion these several conditions grow up *pari passu*, or successively, and appear as factors of the deformity. The time has arrived when it may be said that the majority of the above conditions are but consequences of a common cause,—a weakening of the fibrous structures and bones affecting the knee joint, which becomes statically disturbed by gravity, by passive muscular action, and may even be influenced by the will of the patient in his efforts to effect locomotion in the least uneasy manner when the distortion has reached the highest stage; and through inability of the patient to take any exercise the members may become surrendered to the passive adaptive shortening of muscles, and get more or less rigidly fixed in the deformed state.

One of our ablest surgeons, author of a 'Monograph on Genu-valgum,' Macewen, attributes it exclusively to rickets, and in particular to curvature of the lower end of the femur and hypertrophy of the internal condyle and adjacent part of the shaft. It may here be remarked that curvature of the tibia is sometimes a more prominent fact in rickety genu-valgum (see fig. 7) than femoral curvature, or inward inclination of the knee joint itself.

FIG. 7.

*Rachitic genu-valgum and curvature confined to one leg, from Mayer.*

We refer knock-knee in all its forms primarily to relative or absolute weakness and relaxation of the structures composing and surrounding the knee joint, the ordinary state of perpendicularity of the whole limb being disturbed through the weight of the head, upper extremities and trunk being too great to be properly borne by the enfeebled

and strained knee structures. It follows that the resulting distortion of the articular surfaces in genu-valgum, whether preceded by the weakness of over-growth, by rickets, by paralysis, or by articular disease, should present more or less similar *mechanical* altered relations in all cases.

The minute pathological conditions, when fully known, will probably be found to differ as much as the constitutional conditions of the system at large differ in the several causatory disorders above named. C. Hueter and Mikulicz have ably demonstrated the minute changes of the articular ends of the bones, as shown by microscopical examination in genu-valgum caused by the action of rachitis. We are at present ignorant of the minute changes in the bones and fibrous structures of children fed on too watery a diet, and in paralysis and other causes of the distortion.

In confirmation of this view, that however different may have been the primary constitutional condition, and whatever the secondary or determining causes, either in infancy or adolescence, such as over-much standing or walking in the former, or the pursuit of particular occupations necessitating much standing and carrying heavy weights in the latter, the *mechanical* conditions are the same, we may quote C. Hueter's (*op. cit.*, p. 263) emphatic assertion. We premise that Hueter appears only to have met with three forms of genu-valgum: the rachitic, beginning in young children; the statical, as he erroneously says, arising only in growing youths without obvious rickets; and the traumatic. He says: "When I reflect upon the number of cases of both kinds which I have watched, I believe them to be essentially different, not, it is true, in relation to their clinical symptoms and pathologico-anatomical results,—for these are in both forms identical,—as they are also in their chronological, etiological, and therapeutical relations." We consider Hueter to be quite mistaken in attributing identical clinical symptoms and anatomico-pathological results to rachitic

in-knee which begins in childhood, and the statical which he believes originates only in adolescence. Pathologically, as well as clinically, rachitic genu-valgum is in the early stages distinguishable from all other forms by its being complicated with curvatures of the shafts of the thigh and leg bones, as well as by rachitic affection of other parts. See further on as to co-existence of two forms of disease.

In studying the subject of the influence which the natural form and relations of parts concerned in the knee joint may exercise upon the production of genu-valgum, it becomes necessary to review some of the opinions of surgeons upon it. This is especially needed, as many believe that the distortion is due to the naturally greater length of the internal condyle. Some, speaking of the *normal* femur, have attributed too great an excess to the normal internal condyle. Holden,* for example, attributes to the internal condyle an excess of half an inch. When handling the bone, or suspending it, it may be looked at in an unnatural position. Naturally, the femur is attached to the trunk in such manner that its lower portion inclines towards the median line of the body sufficiently to bring the two condyles on nearly the same plane, so as to correspond with the two usually nearly level articular surfaces of the tibia. This fact disposes of the notion that the internal condyle, being naturally half an inch longer than the external one, acts as a direct cause of genu-valgum.

In the annexed fig. 8 are represented two femurs, taken at random from amongst others. The first (*a*) is a well-formed bone of a tall, probably slender individual, in which the length and breadth of the internal condyle are, according to the norm, greater than of the external condyle. When placed as nearly upright as possible against a wall it is seen that the prominence in *a* of the internal condyle below is very small, and is only sufficient to occasion the slight

* Holden: 'Human Osteology.'

natural obliquity or adduction of the shaft. The other bone (*b*) is shorter, heavier, possibly from rachitis, more bulky in

FIG. 8.

FIG. 9.

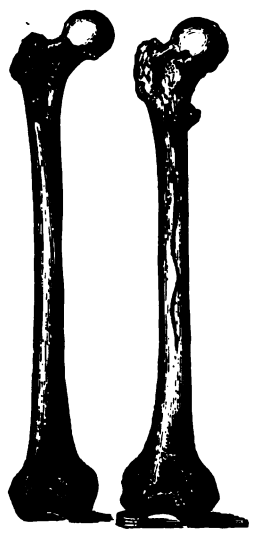



FIG. 8.—*Front view of two femora: (a) normal bone; (b) believed to be taken from a rickety subject. They were photographed, the lower ends resting on a horizontal table, and the upper ends resting against an upright wall.*

FIG. 9.—*Copy of photograph of the front view of the same two femurs: (d) has the longer internal condyle, but on contrasting (b) and (d) it will be observed that the placing three bronze pennies beneath the external condyle suffices to produce in this photograph the same inward inclination of the shaft of the thigh as (a) and (c) exhibit.*

all respects, except as to length; all the processes and the caput much more pronounced, and the neck more horizontal; probably the bone of a stouter individual, and one accustomed to carry heavy burdens. This second femur, when similarly placed resting upon the table and against the wall, as nearly upright as possible, exhibits a greater obliquity or adducted position of the shaft. At *d* (fig. 9) it is seen that three penny bronze pieces (= 0·18 inch, or

4·57 millimetres), placed beneath the external condyle, are all that is required to give this second bone the appearance of possessing the smaller degree of obliquity or adduction of the shaft, as in the neighbouring bone (*c*). We next direct attention to *e* and *f* (fig. 10), which represent the back view

FIG. 10.

*Copy of photographic back views of the tibiæ* (*f*) *and* (*e*), *corresponding to the above femurs:* (*e*) *the back view of tibia, which corresponds to the femur* (*b*) *and* (*d*); (*f*) *is the back view of the tibia, corresponding to the femur* (*a*) *and* (*c*).

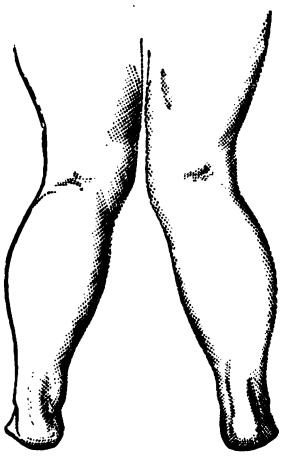
of the two tibiæ corresponding to these femora, and note that the femur *b* and *d* (in figs. 8 and 9), which has the longer condyle, has the deeper articular cavity for its reception, as seen at (*), compared with the articular cavity at (†). Assuming that these femurs represent comparatively small development of internal condyle, we consider that they show that the relative normal superiority in length of the internal condyle has been much exaggerated.

In like manner it may be inferred that the abnormal enlargement of the internal condyle of the femur in genu-

valgum has been unintentionally exaggerated from observers having in their estimate compared it to the external condyle, the development of which has been reduced below the norm by absorption through undue friction and bearing upon it.

A clinical examination of the form and relation of the bones in the very young, affected with non-rachitic genu-valgum from weakness, shows that enlargement of the internal condyle does not at that period exist. See fig. 11. There is prominence of the knee on the internal aspect ("in-knee"), but not increase of bulk, either of that condyle or of the neighbouring internal part of the tibia. In the very young this prominence immediately disappears, when in the gentlest manner the limb is straightened with the hand. Gradually, however, during the persistence of the distortion, and the constant strain and stretching in walking and standing, which is experienced by all the structures on the inner aspect of the knee joint, when the distortion is not arrested in early childhood, some thickening and deposit in the structures, bone, periosteum and ligament, take place. These changes may be the result of altered nutrition and growth of bone through prolonged afflux of blood to the part under influence of strain.

FIG. 11.



*Moderate amount of atonic (non-rachitic) genu-valgum in a very young child, seen from behind; reduced from a natural sized actual tracing from the limbs, to show prominence of the internal condyle, but no enlargement of it in this stage.*

In 1842-3 (Lectures in 'Lancet') the author said, "Besides curvature of leg bones the internal condyle of the femur *becomes* (with the progress of the distortion) very prominent, and sometimes disproportionately enlarged, whilst

the development of the external condyle is impeded." These changes are in some cases denoted by the aching pain and sense of weakness complained of at the part as age advances, and as the demands upon the powers of locomotion, especially amongst the poor, increase.

Fig. 12 is a fairly typical example of a child who could stand and walk alone, affected with atonic genu-valgum of both limbs. Compare with the above a case of moderate knock-knee of rickety origin, in which loss of symmetry is very marked (fig. 3, p. 6), not owing alone to the distortion, but also from the marked swelling of the ends and smaller swelling of the shafts. The annexed diagram A (p. 27), of left knock-knee, will afford an idea of the mechanical relation of the femur and tibia before and after restoration of form. The outline (*a*, *c*) is supposed to represent the left femur of fig. 3, and *c*, *h* is supposed to represent the leg or the tibia before recovery; the dotted outline, ending below at *d*, is intended to represent the leg brought into a straight line with the trunk, as it immediately becomes in a successfully handled or instrumentally treated case of well-marked knock-knee of a very young child. When an atonic case, and occasionally a half-cured rickety one, is gently handled and straightened by applying the palm of one hand against the inside of the knee, at *c* in the diagram A, and the other hand against the outer malleolus, at *h* in the same diagram,

FIG. 12.

*Slight atonic double in-knee.*

there results—as shown by the dotted outline ending below at *d*—a triangular gap (*e*) between the supposed articular surface of the femur and the opposing surface of the tibia.

The surgeon, when examining in the same manner the child's living limb, may feel this triangular gap, into which, but for the integuments, fascia, and ligaments, he might almost introduce the tip of his finger. This gap represents a space equal to the amount of the existing deficiency in length of the external condyle, and the corresponding articular facet of the tibia, augmented at this early stage of the distortion by the laxity of ligaments.*

Diagram A.

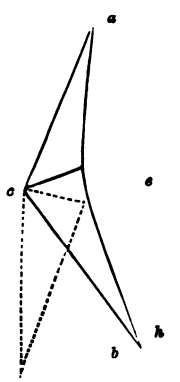



*Diagram of left knock-knee, from Little, on 'Deformities,' 1853, p. 218: (a) femur; (b) tibia; (c) the projecting knee joint of genu-valgum; (d) dotted lines representing the tibia placed in its natural relation; (e) gap left on outside of the joint, when temporary replacement is effected.*

The surgeon, by the most gentle handling, has removed all prominence of the internal part of the knee and of the internal condyle, and therefore all deformity has at once disappeared. The limb has recovered its natural symmetry. He is cognizant of an unusual space between the external articular surfaces of the femur and tibia, due to deficiency of the *external* condyle and to relaxation of ligament from the fact of feeling the gap between it and the outer part of the articular surface of the tibia, and because when holding the thigh immovable with one hand he can with the other, by moving the leg to and fro in the horizontal plane, recognise an unnatural "play" in the knee joint, "wobbling" ("Schlottern"), and is able at will to produce genu-valgum, or the normal position and symmetry. This normal position is temporarily produced by him, for with his hands

* Little: 'Deformities of the Human Frame,' 1853, p. 220.

he holds the joint straight, in the same manner as he could effect straightening in an anatomical specimen by placing a wedge between the external condyle and the opposite part of the tibia. It is possible that the surgeon, if he improperly applied adequate force, might convert the in-knee into the opposite distortion (genu-extrorsum); but if he uses no more than the gentle pressure we have spoken of, he will merely straighten the limb, and will be unable to introduce the tip of the finger between the *in*ternal condyle and tibia, as he was able to do on the external side of the joint.

With increasing age and recovery of tone the looseness of the joint in the extended position ceases, but the deformity produced during the atonic stage continues (if unattended to), and afterwards increases through statical influence. The gap also ceases to exist, but from clinical observation and post-mortem anatomical sources of information, derived, as will be shown, from the labours of Sandifort, Mayer, and Mikulicz, we have evidence of the pre-existence of the gap during the early stage (atonic), in the fact of the observed wide space interposed between the external condyle and opposite surface of the tibia when the femur and tibia are straightened, as regards one another, and placed in their normal relation. See figs. 13 and 14. We may affirm, also, from our therapeutic experience from instrumental treatment, by means of which we assist Nature to deposit new bone where the gap from deficiency existed (pp. 29, 30), and from the effects of supra-condylar osteotomy (Macewen), which gives length to the limb on its outer aspect, whereby the genu-valgum is cured, that a wedge-like portion of bone has been substituted, supplying in the shaft of the femur the deficiency previously existing at the outer condyle.

This gap (fig. 20) is a measure of the amount of bony deposit which, during curative treatment by use of mecha-

nical splints or other appliances, the orthopædic surgeon attracts to the external condyle and opposite surface of the tibia, *i. e.*, renders deposit of bone possible during the progress of growth by relieving the outer condyle and tibia from the pressure it undergoes when walking is permitted, so long as the limb has the form of knock-knee, and thus brings about a lengthening of the external condyle and heightening of the external part of the articular surface of the tibia, and, together with recovered tone in the fibrous tissues, effects a cure. This cure consists of no temporary replacement of parts, but is an instance of the true art of medicine, that of being the "interpreter and helper of Nature." For over a generation we have watched with the deepest interest the repetition of this phenomenon of nature's masonry in repairing an arrested development of bone in the limb of the young child, and in adolescents, at the oppressed external side of the femur and tibia when the shafts have been relieved from undue pressure by proper interference.

This therapeutic practice proved, as was expected, that when released from undue pressure the external condyle and neighbouring part of the shaft of the tibia would, at least in the young child, grow into and fill up the space provided by the treatment for it; in short, that the femur and corresponding part of the tibia in the progress of growth and development, when released from accidental obstacles, would revert to the natural physiological type. C. Hueter, speaking in 1877 of his method of successful treatment of these cases,* which will be described in the section on treatment, says:—"I reckoned on the disposition of the cartilaginous tissue in rachitic cases to exuberant expansive growth, and fancied that in rachitic children affected with genu-valgum the undue depressions in the articular surfaces would rapidly fill up (by cartilaginous cell proliferation), as soon as, for a short time, the undue weight could be removed

* *Op. cit.*, p. 264.

during standing and walking." We have had ample experience that the same Nature's mode of cure comes to pass in other than rachitic cases.*

In a course of lectures, published in the 'Lancet' in 1842-3, we described this *adaptation* of the articular surfaces to the change of their relation effected during the treatment. In the work on 'Deformities,' already quoted (see note, pp. 216—218), when speaking of a severe case, treated in a young adult female by instrumental means, it was shown that even in such a case the gap caused by deficiency on the external parts of the articular surfaces, when the tibia had been brought into a straight line with the trunk, may become filled up. At that time the author wrote:—"It was an interesting question whether, as the patient had reached full growth, the articular surfaces of the femur and tibia would adapt themselves to their altered relation. Confiding in the extraordinary powers of adaptation manifested by articular surfaces during treatment of severe club-foot, I trusted that, although the growth of the body was completed, this beneficial result would in time take place, if the position of the legs in the perpendicular line could by mechanical aid be preserved. This result did occur. For several years afterwards we received an occasional visit from this patient. She ultimately lost all trace of genu-valgum," and walked two or three miles, needing no mechanical support. She would have walked longer distances if she had not also suffered from scoliosis. Notwithstanding the publication of these experiences a generation ago, a justly distinguished surgeon has written as to this matter, that "he had heard it said that cases could be cured by mechanical means, but he had had no experience of it."

* The reader may be here reminded that C. Hueter, in my opinion erroneously, believes that all cases of in-knee in children are of rachitic origin.

Enough has been stated to justify the formal assertion that deficiency in length or arrested development through pressure of the external condylar part of the femur, and not an excessive length of the internal condylar part, is the primary characteristic anatomical feature of knock-knee in the child's earliest years, as announced by us so long ago as 1842. Several surgeons, who have recently written on genu-valgum, have based their respective operations performed for its relief upon the opinion that the essential anatomical feature of the complaint is an enlargement of the internal condyle, having ignored the fact of shortening of the external one.

Neither Jules Guérin* nor Bouvier,† who have ably written on rickets, have distinguished the atonic or idiopathic in-knee cases from rickety ones.

Speaking, however, as to spinal curvature, and on the states of it to be distinguished from rachitis, Bouvier (p. 269) remarks: "La déviation latérale du rachis peut dépendre du rachitisme, mais elle se rencontre très souvent aussi [we should have said much more frequently] sans le moindre ramolissement des os, même antérieur à la déformation..... J'écarte toutes ces lesions qui ont plus ou moins d'affinité avec le rachitisme, pour ne m'occuper que de la maladie que Glisson a décrite de main de maître."

Bouvier admits a first period in rickets, which he terms that of atrophy, combined with increased flexibility, fragility, and curvature, but did not notice that deviation of knee inwards is a weakness of the joint, often without curvature or enlargement of epiphyses.

Dr. Newton M. Shaffer,‡ of New York, has recognised

* 'Vues Générales sur les Difformités du Système osseux,' Paris, 1840.

† 'Leçons cliniques sur les Maladies Chroniques de l'Appareil Locomoteur,' Paris, 1858.

‡ On 'Knock-knee and Bow-legs,' New York, 1881.

that there are cases he can hardly attribute to rickets. He says (*op. cit.*, p. 7), in relation to the disorder of nutrition in this distortion: "I wish I could satisfactorily answer the query which here presents, and say what is the cause of this disturbance of nutrition. Is it a process of mal-nutrition affecting the system generally, but finding its principal expression at the knee joint?" We have shown that, although most frequent at the knee joint, the atonic condition of fibrous and osseous structures in question is not confined to the knee joint, for we find it in scoliosis, and in the weakness termed *in-ankle*, which in the advanced stage is termed by us non-rachitic flat-foot. Dr. Shaffer proceeds to say: "Can we make the generally accepted definition of rickets apply to all the cases that are found in these localised expressions of osseous deformity seen in knock-knee? If so, why is it so localised? for knock-knee frequently presents as a strictly-speaking unilateral deformity, and affects only one bone or one articulation. Rickets is a constitutional disease, and is characterised by some conditions which are not always found in knock-knee." . . . . "There is certainly something which remains to be explained regarding the etiology of knock-knee; a something which time and investigation only can develop." . . . . "If we apply the answers which must be made to these questions to the conditions found in the knee joint in genu-valgum, we are led far away from the ordinarily accepted definition of rachitis." . . . . "If we recognise that these changes in the knee (knock-knee), whether inflammatory* or trophic, are not always associated with rickets, we have, I firmly believe, taken a step in the right direction." . . . . "Ligamentous relaxation, *plus* the predisposing cause, whatever it may be, is sure to result in true progressive genu-valgum" if unattended to.

* We have pointed out (p. 3) that pain or inflammation in either atonic or in rickety in-knee only occurs after undue strain in walking, or as the result of a fall.

Whilst this sheet has been passing through the press, the 'Transactions of the International Medical Congress' (London, 1881) have come to hand. It is satisfactory to find that several observers concur in the view published in these pages that several varieties of in-knee distortion exist. Thus Mr. H. F. Baker, during a five years' residence at the Royal Orthopædic Hospital, London, watched nearly 800 cases of genu-valgum, and in nearly all of them the distortion took place at the joint itself, and was quite independent of the bone curvatures.

M. Jules Guérin (vol. iv. p. 201) describes four forms, and has noticed the "gap" described by us, p. 27, for he remarks that "*redressement*" leaves a wedge-shaped interval capable of holding the finger, but which diminishes from without inwards." On the contrary, speakers at the Congress, as at the Pathological Society's discussion, 1880, attribute almost every case of in-knee to rickets, they having fallen into the same error into which all fall who have only a comparatively short experience of this distortion, as we ourselves had when we wrote on this subject over a generation ago.

Dr. Shaffer* is an able and watchful observer, and has largely shed light over several distortions, thanks, in part, to the opportunities afforded him as Surgeon to the New York Dispensary and Orthopædic Hospital. Another step in the direction he has set out upon, will lead him, we believe, to the recognition of the accuracy of the views we are developing in this work, that atonic or idiopathic in-knee deviation should be entirely dissociated nosologically from rachitis, and that it originates during the growing age of the individual, but especially often during the most active periods of growth, *viz.*, during the first years of life, at or

* Dr. Shaffer's memoir, the title of which we have given, will well repay the reader who desires further to investigate the pathology of in-knee.

about the age when healthy children first walk, and during the accelerated growth which accompanies advancing puberty. The failing to recognise infantile non-rachitic, as well as rachitic, in-knee, has probably been caused by the fact that either condition may arise in infancy, and because both the *distortions* continue until or after puberty.

The fact of the origin of atonic or idiopathic in-knee during puberty has increased the difficulty. It has required of us many years of observation, and larger public and private opportunities, to surmount the difficulties and doubts which, for example, Shaffer describes himself as entertaining. Authors have overlooked the emphatic statement of Jules Guérin: "Le rachitisme est exclusivement une maladie de l'enfance."*

The fact in the history of infantile rachitic in-knee, and of curvatures of the thigh and leg bones, *viz.*, that these are sometimes met with at birth, appears at first view to negative our opinion that all cases are influenced by gravity as an external causatory agent. It is certain that within the womb gravity in its ordinary sense cannot affect the fœtus in the manner in which it affects the infant when, at about nine months to a year old, it is attempting to walk.

Gravity in the *infant* labouring under weakened passive structures of the organs of locomotion is an external determining agent. If the fœtus within the womb be affected with the constitutional disease termed rickets, so that the ligaments and long bones of the lower limbs have less than their proper development as to firmness and power of resistance to the external forces to which in the womb they are exposed, they might be expected to yield to such external influences as they may be exposed to within the womb, as readily as infants do without the womb. The external influences in question are pressure against the

* 'Memoire sur les caractères généraux du Rachitisme,' Paris, 1839, p. 21.

walls of the uterus and the parietes of the abdomen, the vertebral column and pelvis of the mother.

In the normal stage of the fœtal development we know that the organs of the mother are so adapted, the Liq. Amnii is so abundant, and the head, trunk and limbs of the fœtus are so arranged, that at birth no signs of too close packing or of distortion are perceptible. Obstetricians have, it is true, noted as an occasional circumstance that the hips and knees of the new-born child have been found unduly stiff and slightly contracted, a condition which we know spontaneously subsides, or is cured within the month by the nurse's rubbing. Other observers have said that this contraction at birth exists in all cases.

At any rate, it may be assumed that in the uterus, the fœtus—with the placenta, the membranes, and fluid—has ordinarily no more space at disposal than is necessary, and we know that sometimes space is deficient. We see, therefore, that the fœtus in utero, besides being liable to rickets, to accidental fractures, and fractures from action of its own muscles, is exposed to such mechanical forces external to its own organism as would be likely to occasion curvatures of the long bones, and not improbably genu-valgum, in the few cases in which it has been met with as a congenital affection.

It should also be here remarked, that amongst the causes *internal*, both to the fœtal and infantile organisms, which are capable of thus modifying the form of the joints and long bones, a disturbed spasmodic action of the muscles upon them should be reckoned. (Rétraction musculaire of Guérin.)

Von Ammon* gives drawings of several cases of considerable congenital genu-valgum. But these appear to be ordinary non-congenital genu-valgum, of which they have

* 'Die angeborenen Chirurgischen Krankheiten,' Berlin, 1842, Tab. xxvii.

all the characters. Experience teaches that the statements of grown-up lads and adults as to congenital origin of deformities cannot be conclusively relied upon. We have never met with, during infancy, a marked *congenital* genu-valgum. We do not, however, dispute that fœtuses affected with a series of distortions have also presented in-knee deviation from spasmodic causes.*

When in-knee deviation presents itself in relaxed, weakly children, who have neither walked nor have been prematurely incited and assisted to try to stand and walk, the influence of the weight of the upper parts of the frame upon the weak knees might be rejected. It should, however, be remembered that long before a suspicion of weakness or backwardness in using the lower limbs has arisen, the child, as is usual and proper, has been at least accustomed to try and walk up the nurse's lap. For a similar reason it might be objected that in acute and chronic knee joint inflammation, in which after a time knee inversion is apt to occur, gravity is less likely to have become the determining cause of the morbid inversion. To this objection it may be remarked that in the majority of cases, when the acute stage of disease has subsided, the patient too frequently attempts prematurely to use the part, and it is in the later stages that the morbid inversion is noticed. Moreover, as may be read hereafter, the experience of the influence of gravity in genu-valgum from local disease, as in the other forms, does not exclude, as we have already shown, the co-operation of muscular contraction, when by the effect of disease and effusion upon the ligaments, which in health bind together and support the articular ends of the femur and tibia, they are distended and loosened, the joint becomes a prey not only to mechanical external causes (gravity and evil position), but to the action of muscles.

We have evidence that even a perfectly sound knee may

* 'Œuvres du Docteur Jules Guérin,' Livraison 1er, Paris, 1880.

become affected with genu-valgum. Thus it is a frequent occurrence that a healthy person born with a congenital defect of one lower extremity, or a person who has become stricken with slight general infantile paralysis of one lower extremity, or who has met with an accidental injury of it, from all which causes a weakening of the member results, and that, whether or no, it becomes affected with genu-valgum, it (the defective limb) is at all events unable to do its full share of work in the labour of locomotion. The lame leg makes as many steps as the sound one, but the individual, after each step, does not rest so long upon it as he does upon the sound limb; hence the "quick" halting, unrhythmical gait of many lame persons. Besides which, the labour of propelling the body onwards falls unequally upon the two limbs. The lame one may not expend one-fourth of the energy and force in the act of propulsion and movement in locomotion which the sound limb does. The result is, that after a few months or years, the sound limb of the most healthy individual may give way at the knee, presenting a distinct degree of genu-valgum, accompanied for the most part with a corresponding degree of flat-foot (spurious valgus).

We learn from this fact, and others, of daily occurrence in children, adolescents, and adults, that the human lower extremity—*i. e.*, its bones, ligaments, and muscles—is constructed only for a suitable maximum amount of work, even under the best conditions of climate, food, alternation of rest and fatigue. To repeat, we conclude that the limb of a growing infant, who came into the world without cognisable defect, and had been supplied with the best motherly and hygienic surroundings, is only provided with the energy and force suitable for the maximum work the limb of an average robust infant has to perform.

We cannot be surprised, then, that the absence of breast-milk, and the substitution for it of a watery, poor, or un-

suitable diet, the nutrition of the infant should be so impaired that, without the institution of a specific disease—rachitis—the fibrous tissues should so lose in strength and toughness that the important knee joint is incapable of withstanding the strain of the comparatively light office it has at that age to perform, and that it should yield in the direction which the anatomical arrangement favours.

It has long been laid down that "there exists no aberration of form without alteration of structure."* At pp. 15, 21, we have touched upon the question of the morbid anatomy of the fibrous structures in hand-fed infants affected with in-knee. Fortunately these cases recover so quickly during early infancy, by two or three months' employment of suitable diet, hygienic influences, and attention to topical remedies (see treatment of in-knee), that no opportunity has been afforded us for anatomical research. We have had to content ourselves with a clinical diagnosis between the non-rachitic and the rachitic forms.

It will be remembered that we have dwelt upon the fact that in atonic in-knee the ligaments snd muscles are relaxed in the early stage, but become tightened up in the adolescent and confirmed stage, through their adaptation to the persistent deformity. In fact, it is found in the confirmed stage that the knee resists the efforts of the surgeon's hands to restore it to the natural shape.

We consider that in a confirmed case, whether originally idiopathic, atonic, or rickety, the internal lateral ligament is only so much stretched out as is required for accommodation to the displacement which the inner part of the knee undergoes in consequence of the abduction of the leg.

It will be noticed farther on that Mayer described his having found after death all the knee ligaments relaxed in an atonic or idiopathic case, aged sixteen, of several years' duration. He was not aware of the true explanation of this

* Trinquier: 'Gazette Medicale de Montpelier,' January, 1844.

fact. He narrates that the case had previously been under his mechanical treatment. We have no doubt that it had been played fast-and-loose with, and that the looseness was not a character of the deformity at that stage, but an artificial result of the treatment. See a similar case of an adult female treated by us (p. 30).

Mayer's case in question illustrates the remark we have already made that surgeons have often failed to discriminate the difference of condition of a given case of distortion in its early and in its latest stage, and, we may add, overlooked the share which incomplete or improper treatment has artificially produced.

We are led to dwell here on the influence of lengthened or shortened ligaments in genu-valgum, because, soon after Mayer's writings appeared, an important addition to the knowledge of the morbid anatomy of the ligaments and bones was made by Professor Linhart, a fellow-townsman of Mayer.*

Science is indebted to Mayer and Linhart for morbid anatomy observations in adult cases. Neither of these pathologists dissected young cases, or surmised that the conditions might be different in the first stages of the complaint, especially in early childhood. In opposition to those who believed that the internal lateral ligament was relaxed and weakened, and thus favoured the production of knee inversion, Linhart stated that this ligament was thickened to a remarkable extent, so that, as he writes, "those surgeons who are disposed to regard facts from a teleological side would rejoice that Nature has done so much to prevent internal luxation (projection) of the femur." †

* 'Ueber Erschlaffung, Atonie der sehnigen Gewebe,' von Dr. W. Linhart. 'Vierteljahrschrift für die praktische Heilkunde,' Prague, 1859.

† As to genu-valgum, Linhart errs in using the expression "luxation." The insertion of the word "projection" is a correction of ours.

The undue tension and stretching of this ligament is apt to be accompanied with hyperæmia. This "ubi irritation ibi affluxus" leads to augmented nutrition—hypertrophy. If the strain upon the ligament be not arrested by treatment, the hyperæmia may lead to inflammation; experience of the worst adult cases, however, shows that the stage of inflammation in ordinary atonic and rachitic cases is not reached, unless other causes, such as a fall or rheumatism, be applied.

From our own clinical observations in atonic infantile non-rachitic cases, especially from the before described (p. 27) lateral mobility in them, we consider it to be proved that all the fibrous structures—lateral, capsular, inter-articular ligaments, and the muscles—are relaxed, so that they abnormally yield beneath the influence of gravity, and thus the distortion is produced. When, however, the nutrition of the individual has improved, the relaxation of these structures is replaced by a natural tonic condition of them, so that the articulation loses its previous mobility, and becomes more or less set when the knee is extended in the deformed shape, owing to changes in the component parts of the joint which the progress of the disorder produces.

The subject of tone of tissues, and its deficiency, has little engaged the attention of pathologists, except in regard to muscles. Any aberration of innervation of these, connected with nerve supply from the nerve centres, is either spasm, paralysis, or loss of power of co-ordination. We consider the tone proper to a healthy muscle to be that condition which results from proper nutrition and proper exercise of it. A deficiency of tone of muscle arises from defective nutrition and want of proper exercise. In like manner we believe that other structures—the ligaments, fasciæ, and even the skin—are kept in a state of tone when the nutrition and the general hygiene are perfect, and lose tone when nutrition and hygiene are imperfect.

Further on we shall adduce other evidence, which has led us to the conclusion that the largest number of cases of in-knee are due to atonic causes, and not to rickets. Atonic in-knee appears to us to present characters entirely different from rickets. We have asked ourselves whether atonic in-knee may be the earliest stage of rickets. We have put this question to ourselves from our search after pathological truth, and out of respect to the number of able men who have preceded us, who have, from our own point of view, failed to discriminate between infantile and atonic knock-knee, which occurs both as an adolescent affection and rachitic knock-knee, which is also an infantile *disease*, but is one which is exclusively infantile.

Linhart, in the single case, already alluded to, found the *external* lateral ligament not tense or contracted, but puckered up in its sheath in a wavy manner.* He found the crucial ligaments normal, and was the first to mention the finding in an adult case a curvature of the lower part of the diaphysis of the femur, the convexity of which was directed inwards. "It was not an abrupt sudden bend (keine knickung), but a considerable bow of the whole lowest third of the bone." This is the curvature in the femoral diaphysis, since so much dwelt upon, as will be seen, by Mikulicz and Macewen, as if it were certain that it is an invariable condition, they not having discovered the existence of non-rachitic forms. Linhart recognised the importance of this twist in the femur, even in cases in which the difference in the length of the condyles was but slight. He states that he has observed this particular twist "in the living, and not unfrequently in cases which were congenital, or those of young children." The use of the preposition "or" in the last sentence seems to signify that, according to him, *all*

* *Op. cit.*, p. 90. Linhart's words are: "Dieses Band nun fand ich in einem Falle innerhalb seiner Scheide wellenförmig gekrummt, also (im Gegensatze zu Spannung) erschlafft."

infantile cases are congenital, which is only true of rickety hereditary cases.

Mayer and Linhart mention the not infrequent occurrence of a *wobbling* (Schlottern) looseness of the joint; and in the worst stage of in-knee Mayer distinctly states that the case in which he observed this symptom was a severe adolescent one, in which, as we have already stated, instrumental treatment had been long ineffectually employed. As Linhart speaks of this symptom as occurring in the worst stage of in-knee, we may confidently assume that he refers to adolescent or adult cases, because the worst stage is never reached before advanced adolescence or adult age. We have never seen this symptom in the adolescent or adult, except as a consequence of defective, interrupted, or non-continuous use of mechanical means (p. 39). The undue lateral mobility of children, aged twelve or fifteen months to two years, especially of those who have only walked a few weeks, is more remarkable, when the actual distortion is comparatively very slight, than in older children, in whom the distortion is more pronounced. Linhart has described, under the words, "atrophy* of the external condyle of the femur and opposite external part of the tibia," the condition of things which we described as the most essential abnormal anatomical peculiarity in advanced genu-valgum, in 'Deformities of the Human Frame,' 1853, p. 218.†

In these cases Linhart found the ligaments unchanged, —neither softened nor attenuated, but, on the contrary, often tougher and stronger (derber).

* Instead of the word "atrophy," we have expressed the wasting of the external bony parts of the joint by the terms—compression, deterioration, and absorption.

† Mayer and Linhart were the first who, as far as we know, followed us in regarding the damage to the external portions of the joint as of primary importance, compared with that of the morbid increase of the internal condylar parts.

So little attention had, until recently, been paid to the morbid anatomy of deformities, except by orthopædic surgeons and physicians, that Rokitansky, 'Manual of Pathol. Anatomy,' edit. 1849 to 1854, Sydenham Soc. Translations, does not even mention the morbid anatomy of congenital club-foot, or of in-knee.

J. Cruvelhier ('Anatomie Pathologique du Corps Humain,' Paris, 1829–39) appears equally silent as to genu-valgum; and so are the Transactions of the London Pathological Society, published previously to 1881.

It is only since the introduction of tenotomy that the attention of the pathologist has been directed to the morbid anatomy of knock-knee, consequently illustrative specimens are rare in anatomical cabinets. Our knowledge of the subject was formerly mainly confined to clinical observation. We were thus enabled to show that, whatever the primary etiological influence might be, and we then believed that the majority of cases of genu-valgum were of rickety origin, the mechanical changes of relation of the articular portions of the thigh and leg bones which ensue were identical. Formerly we were able to discover in medical literature only one anatomical observation and description of the physical changes in form undergone by the knee bones in genu-valgum, that of Sandifort, though not so designated by him, in his 'Museum Anatomicum,' vol. iv., pl. 29, which is here reproduced. (See fig. 13.)

Sandifort attributes this example of genu-valgum to "hydrops articuli," from which the softening and subsequent hardening of the bones may possibly have proceeded; but his description corresponds with advanced rachitic genu-valgum. He says:—"Forma nimirum ossium, ubi articulationem componunt, maxime est mutata; æque ac si hæc ossium extrema in prima morbi periodo, quando emollita fuisse videntur, graviditate corporis compressa, præternaturalem hanc acquisiverint figuram, quam dein,

duritie ossis rursus aucta, retinuerint, dum post illud tempus marginum superficierum articularium excrescentiæ procul dubio exortæ sunt."

Fig. 13.

Fig. 14.

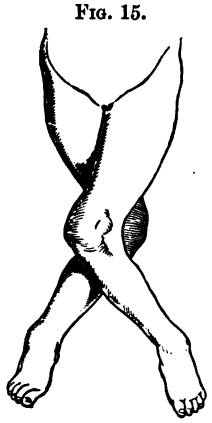
Fig. 13.—*Illustration of the change of form and direction of the articular surfaces and shafts of the femur and tibia, which may ultimately ensue in what we believe was rheumatic genu-valgum, from Sandifort. The extreme obliquity of the articular surfaces is apparent, as well as the thrusting or crushing upwards, and absorption at the expense of the external condyle, whilst the internal condyle has grown downwards and inwards, apparently from meeting with no hindrance in those directions. Considerable indications of cauliflower exuberant growths of bone foreign to our present object in this section are also present. This figure was published by us in 1853.**

Fig. 14.—*The same bones placed by us nearly in their natural relation, to show the gap between the external condyle and opposite part of the tibia. The artist has placed the femur in a too perpendicular position, a circumstance which only slightly affects the fact which the figure illustrates.*

* Little: on 'Deformities of the Human Frame,' p. 211 *et seq.*

We are indebted to A. Mayer* for the next step in positive knowledge of the morbid anatomy. He describes a non-rachitic, but atonic, case of genu-valgum, in which the patient, a boy, walked well up to the age of nine years, when he had severe pertussis of seven months' duration, became wasted, and had so great relaxation (erschlaffung) of the ligaments of the knees that from this period the knees began to incline inwards (*op. cit.*, p. 16). During four years he hobbled about, until marked knock-knee, the result of statical influence, was discovered. At the age of fourteen the lameness was no longer dependent on local weakness. The thigh and leg bones began to participate in the disorder, inasmuch as the external condylar parts of them, owing to friction and absorption, became flattened, whilst the internal condyles of both femora became enlarged and prominent. From the age of sixteen the knees began to cross over one another (see fig. 15), and the feet to assume the form of flat-foot. At the age of eighteen Mayer removed a wedge of bone from both tibiæ. Notwithstanding certain difficulties, he had the satisfaction of seeing his patient's lameness removed. Unhappily the patient died from tetanus two months after operation of the second foot, apparently through sitting on wet grass. Mayer, who was the first to employ osteotomy for the cure of knock-knee, was able from a previous twenty-five years' clinical study of this distortion, in his private Orthopædic Hospital in Wurzburg, to start on his career of osteotomy with a large stock of knowledge of the different forms of the deformity. As with pioneers in most new surgical operations, his successes were chequered

FIG. 15.



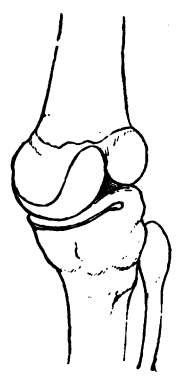
*Extreme atonic in-knee, from Mayer.*

* *Op. cit.*

with disasters. Deaths, after several of his operations, furnished him at least with the opportunity of studying the mechanical conditions of knock-knee. Some of Mikulicz's* anatomical observations were derived from a similar source. A. Mayer, though apparently unacquainted with our earlier writings, has confirmed our teaching as to the influence of arrested growth of the external condyle of the femur, and

FIG. 16.

FIG. 17.



found the external articular opposing surface of the tibia similarly affected, whilst the internal condyle had gradually enlarged.

The two figures above, from Mayer, represent (fig. 16) the right non-rachitic genu-valgum, from which a wedge of

* 'Die seitlichen Verkrümmungen am Knie,' von Dr. Johann Mikulicz. 'Archiv fur Klin. Chirurgie,' von Langenbeck, Berlin, 1879, p. 561.

bone has been removed below the knee previous to placing the leg in a straight line; and (fig. 17) the bones of the similarly affected left knee, which had been successfully treated by osteotomy, and removal of a wedge of bone below the knee four months before. Post-mortem examination of the bones of the knees, Mayer states (p. 22), "confirmed the presence of considerable enlargement of both internal condyles, and considerable flattening of both external condyles, with relaxation of all knee ligaments." It shows, however, another anatomical fact, important as regards treatment, *viz.*, the great obliquity of the line of the articular surfaces of the femur and tibia, from the outer side of the joint, downwards and inwards. The obliquity of this line appears greater in the left limb than in the right, probably from the left having been more affected. In the remarks which follow on treatment we shall derive, we consider, a cogent argument in favour of osteomizing the femur instead of the tibia, and in favour of the supra-condylar operation. We consider the continuance of so oblique a state of things very apt to induce relapse of distortion.

Mikulicz's study of the morbid anatomy of in- and out-knee led to important contributions to the knowledge which has recently been acquired. In his published table of cases he has included some distinctly rachitic with others which have occurred during adolescence from debility, phthisis, and probably over-growth. The grosser anatomical changes of the knee joint, though varying in origin and degree, were similar in all cases, a fact which shows how great was the share of influence in the resulting deformity exercised by circumstances independent of the knee joint or of the normal condition of the internal condyle. We have already to some extent shown that, whichever of the primary causes of inward yielding of the knee has been in operation, the resulting grosser changes of form and relation are the same. It is evident, therefore, that it cannot be correctly stated that

genu-valgum essentially owes its origin to abnormal growth of the internal condyle. In fact, those who attribute inward yielding of the knee to primary enlargement of the internal condyle have mistaken the consequence for the cause.

From the history of several of the cases narrated by Mikulicz as having been attacked for the first time by rickets during adolescence, we are of opinion that they were atonic cases, and not *rachitic*, or, if rachitic, that the slightly arrested rickety *distortion* had been present in early childhood, had been stationary for some years, and had become suddenly aggravated through statical influence and undue weight, carrying and standing, during the adolescent fast-growing period, and not from a second, or from a prolonged, attack of rickets.

Mikulicz attributes all changes of the form of bones, from the influence of gravity, to rachitic softening. He has overlooked the fact that, under the influence of gravity, bones, not rachitic, may undergo changes of form, as in Mayer's first osteotomized case, just referred to. Clinical experience of atonic knock-knee, club-foot, and scoliosis, daily shows changes of the form of bones where no sign of rickets exists.* Cases of genu-valgum from spasm or paralysis of muscles, and from chronic rheumatism, are instances. Compensatory curvature, genu-varum with curvature of the femur and tibia of one leg, owing to the individual having had fracture, ending in shortening of the other leg (without a trace of rickets), is a case in point. So also is the occasional case of a person having atonic genu-valgum of one limb, and what may be termed compensatory genu-valgum of the other, by its getting out of the way.

From the results we have witnessed of the gradual irre-

* Holmes's 'System of Surgery,' article, "Rickets," 2nd edition, by Alexander Shaw; and 3rd edition, by Dr. Little.

sistible force of gravity, we are convinced that the strongest bone of the human body, *continuously* exposed to it in a forced unnatural direction for months and years, would give way under its influence, and become curved in the same manner as we see bones distorted from disease.

This supposition, based upon facts daily witnessed, enables the orthopædist to apply pressure with confidence in the treatment of some distortions, availing himself of the three powers more or less at his command—gravity, muscular action, and gentle gradual mechanical force.

The figures (18, 19, 20), from Mikulicz, satisfactorily represent the different relations of the bones to each other. Fig. 19, the *normal* relation; fig. 20, their relation *in inward yielding of the knee;* fig. 18, their relation *in outward yielding of the knee.*

The perpendicular line in each of the figures, extending from the summit of the head of the thigh bone to the middle of the ankle joint, shows the direction in which, according to him, the limb is laden with the weight of the body. In the normal condition, fig. 19, this line (*a*, *c*) passes almost exactly through and between the middle of both condyles. In a slight degree, owing to the naturally slightly oblique or adducted position of the lower end of the femur, there is a tendency to inward inclination of the knee, rather than to any outward inclination of it. Mikulicz says (p. 581), in reference to this line, fig. 19 (*a*, *c*): "It is clear that in every normal limb, owing to the usual bearing of the weight of the body, an equal portion of it is borne upon both halves of the knee joint." From this observation it might be inferred that the form of the bones of the knee joint and the direction of the line of gravity in health do not favour the production of genu-valgum. The brothers Weber,* and

* 'Mechanik der menschlichen Gehwerkzeuge,' von den Brüdern Wilhelm und Edward Weber, Göttingen, 1836.

most anatomists, give a greater normal inversion of the femur than Mikulicz has done. We consider that in health the line of gravity falls slightly to the inside of the middle

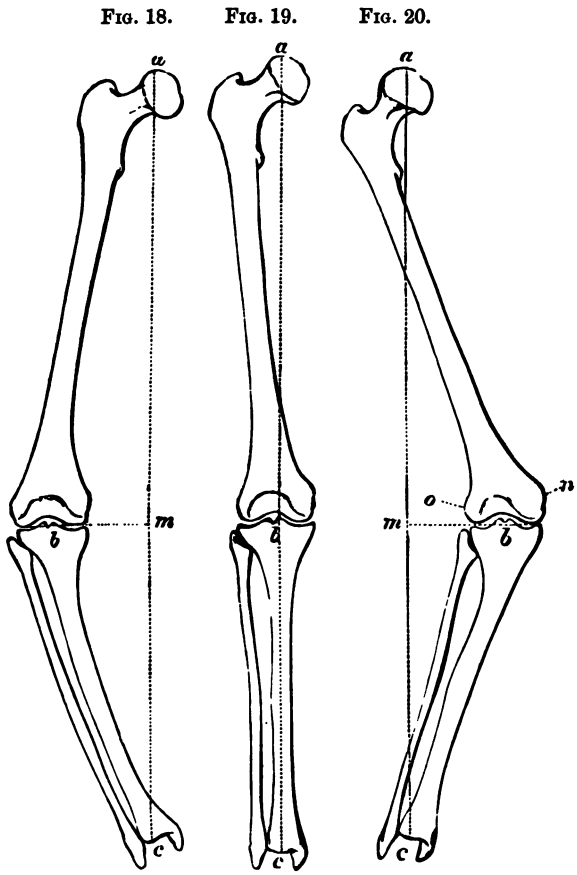



Fig. 19, *a normal limb*; Fig. 20, *genu-valgum*; Fig. 18, *genu-varum*: (*a*, *c*) *line of gravity*; (*b*, *m*) *deviation*; (*o*) *the diminished external condyle*; (*n*) *the enlarged internal one*; *the proportions of these condyles is reversed to some extent in genu-varum.*

of the joint, and that consequently there would in health be a constant tendency in the knee to yield inwards, were this not prevented by the ligaments and muscles of the joint.

Fig. 20 shows that when relaxation and weakness of the ligaments and muscles (atonic), or softening of the bones (rickets), take place, the joint yields inwards, leaving the centre of gravity far to the outside. It is less easy to explain the rarer case, in which the knee yields outwards (genu-extrorsum curv.), fig. 18.

Fig. 21.

To the above figures from Mikulicz, we have added a fourth, fig. 21, which represents Mikulicz's genu-valgum straightened. It exhibits the "gap" we have so often mentioned, as existing in the early stage of genu-valgum, which, now we have put the bones in their normal relation to the perpendicular, requires to be filled up in the growing patient by Nature, adding bone and cartilaginous material on the outer side of the joint when the limb is held straight by mechanical means, as represented by the dotted lines between the outer condyle and opposite part of the tibia. (See also p. 27.) Compare this diagram of straightened knee with that of Mayer (fig. 16), drawn after Nature, which shows that in the advanced stage, when the knee is extended, the biceps muscle and external ligament keep the external condyle and opposing part of the tibia closely applied to each other.

C. Hueter* has confirmed our opinion expressed in 1842, that the weight of the body being thrown too long and too frequently upon the articular tissues, which are too soft and too yielding, is the essential fact in the origin of genu-valgum. He adds, that the external half of the articular surfaces of femur and tibia become arrested in their growth, owing to an excess of weight being impressed

* Dr. C. Hueter: 'Klinik der Gelenkkrankheiten mit Einschluss der Orthopædie,' 1877, 2ter theil, p. 259.

upon them during the rotation outwards of the femur, which attends full extension of the knee. He goes too far in proclaiming that every adult has a minimum degree of genu-valgum.

This small amount of normal inward inclination is doubted also by Mikulicz. He says, that if it existed the weight of the body would in every healthy person induce an in-knee. And so it would happen were it not that in the normal individual the powerful ligaments and muscles surrounding the knee joint support it so effectually, and so thoroughly balance each other, that our clinical genu-valgum is not produced in the healthy and robust, except from over-work or from accommodation. See pp. 11, 37. A proof of the accuracy of this view is afforded by the fact, already mentioned, of its origin from any of the numerous causes which disturb the equilibrium of the thigh muscles, *e. g.*, in certain forms of infantile paralysis, and in spastic contraction of thigh muscles, which sometimes follows asphyxia neonatorum.

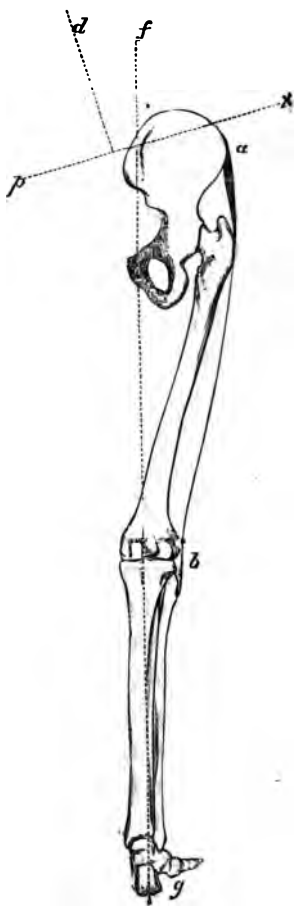
C. Hueter holds the view that the external half of the opposing articular surfaces of the knee becomes arrested in growth, owing to an excess of weight being impressed upon it *during the rotation outwards of the tibia, which attends full extension of the knee.* The rotation in question, in our opinion, is, if any, much less than he supposes. Indeed, as was long since shown by the brothers Weber,* the arrangement of the lateral and crucial ligaments of the joint *in health* oppose rotation outwards of the tibia in the extended position of it. We have proved this from examination of the dissected knee, the ligaments of which had not been divided.

So when we firmly hold together a femur and its tibia, from an anatomical cabinet, in a position of full extension, we are unable to give to the tibia any outward rotation.

* Weber, *op. cit.*, p. 201,

We would say, on the contrary, that owing to the form of the articular surfaces of the femur and tibia, and of the tibial spine, the more the knee is *bent* the more readily can the leg be rotated outwards, and, *vice versâ*, the more firmly the joint is extended the less easily can the leg be rotated outwards.

Fig. 22.




In the figure (fig. 22), the patient being over-fatigued, the knee joint (*b*) has slightly yielded inwards, and the inner margin of the foot tends unduly to the ground (talipes valgus), the outer margin of the foot (*g*) proportionately raised from it, and the toes disposed to be too much everted. The line of gravity, instead of passing through the head of the femur (as in fig. 19) and through the middle of the knee and ankle joints, passes in a line (*f*) through the sacro-iliac synchondrosis and towards the inner side of the heel. The letter (*d*) indicates the direction of the lumbar vertebræ, when, as in this figure, the patient is supposed to rest on the right limb, the left being placed in advance. The line (*p*, *x*) indicates the sinking of the left half of the pelvis, and the raising of the right half.

Whilst we are touching upon the physiological circumstances which may favour or prevent genu-valgum, we may remark that the tensor vaginæ femoris, with its tendon-like

expansion, the fascia lata, appears also to exercise a controlling influence upon both inversion and rotation of the knee. (See *a*, *b*, fig. 22.) We are indebted to Mr. Alexander Shaw for this diagram, intended to illustrate the production of rotatory-lateral spinal curvature. It shows, however, at the same time, the manner in which fatigue is prevented from engendering knock-knee in the robust. Fatigue may produce temporary knee inversion and some flat-foot when the individual stands unduly on one leg; a night's rest in the healthy person removes the fatigue-weakness of the preceding day. But when the fibrous structures suffer from atonic influences (dietetic or other) a night's rest does not suffice to remove the weakness; on the contrary, genu-valgum may be gradually engendered. In health, and freedom from undue fatigue, the tensor vaginæ (*a*), and fascia passing over both hip and knee joints, tend by their tension to stiffen both joints in the extended position to prevent inward yielding of the knee, and enable the individual to rest on one leg, and support the weight of the body with a minimum expenditure of muscular power.

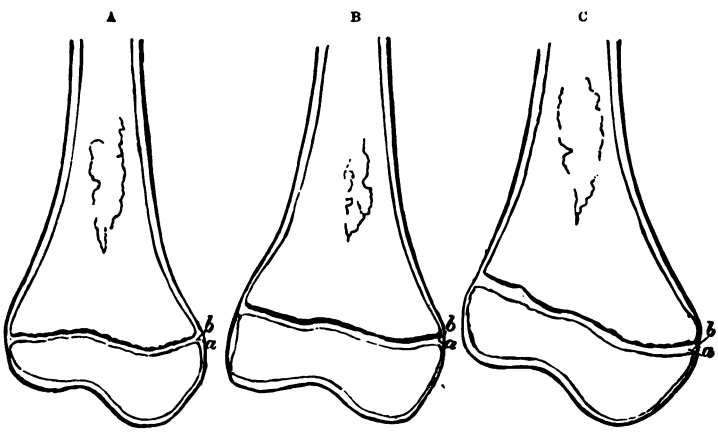
Mikulicz has raised an important question as to the part of the articular end of the femur in which the greatest morbid changes take place. He attributes the changes to unequal growth of the diaphysial border of the bone, in which opinion he is followed by Macewen. Mikulicz says, p. 598: "It is clear that the alteration of length on the inner side of the femur arises not from alteration of the epiphysis, but is confined to the lowest part of the diaphysis." And further on he says: "It is seen that in genu-valgum the unchanged epiphysis is attached to the altered diaphysis in an oblique direction, which is a very characteristic anomaly at the lower end of the femur."

The series of outlines opposite, from Mikulicz (fig. 23), which represent the front section of the femur, taken from a normal subject and from two different subjects of genu-

valgum, enables us to follow the successive increase of the divergence in form and length of the internal and external parts of the lower end of the shaft of the femur.

We consider that the torsion, described by Linhart and Mikulicz, at the lower end of the femur and the smaller bone changes on the upper and internal part of the tibia are statical and adaptive, and that they may occur both in

FIG. 23.




A, B, C *are three representations, from Mikulicz, of the vertical sections of the lower ends of the femur in adolescents and adults, seen from the front:* A *represents a section of a normal femur;* B, C *represent sections of femurs from subjects affected with genu-valgum in advancing degrees of severity: the wavy lines ending* (*b*, *a*) *indicate the junction of each epiphysis with the diaphysis, and show the increasing obliquity of the epiphysial line as the deformity increases compared with the sound bone. The gradual increase of the diaphysial portion of the internal condyle, and to a slight extent of the epiphysial, is shown in* C.

rickety and also non-rachitic cases. We do not doubt that microscopical examination of atonic or purely statical cases will some day show wherein the minute bone formation differs from the norm and from rickets. We may also learn to what extent the texture of the diaphysial and epiphysial parts of the bones are affected during growth, and possibly

afterwards, by the strain experienced there by over-loading in an improper position, and by the hyperæmia sometimes kept up there for months and years during the advanced stage.

Mikulicz states that the epiphyses are not essentially involved (p. 600). We are of opinion that his fig. 23 shows that the epiphysis does increase on the internal half of the articular surface of the femur both in breadth and depth, though in a much smaller degree than the diaphysis. Mikulicz regards the one-sided enlargement of the diaphysis of the femur as a characteristic of genu-valgum.

There is another physical condition in atonic inward inclination of the knee daily observed clinically, especially in the early stages, worthy of mention,—abnormal hyper-extension of the knee joint. This condition is an exaggeration of the normal hyper-extension, and rarely amounts to double the normal limit. It is a state of things not to be overlooked in treatment. We have observed that in infantile unmistakable rachitic genu-valgum the knees are apt to be found unduly flexed, and slightly contracted and stiff, rather than affected with hyper-extension or laxity. However, in the advanced stages of rickety in-knee, in which instruments have been long unavailingly used, much hyper-extension may exist.

An important pathological fact is that the distortion disappears when the joint is bent. So universally is this the case, that it may be regarded as the pathognomonic sign of simple genu-valgum.* There is no other single fact which holds an equal position. Various opinions as to this disappearance of the distortion have been offered.

We believe the true explanation to be that, however much the condyles of the femur in knock-knee may differ in length

* We have shown (p. 10) that there are several simple forms of in-knee as well as sub-forms, in which the in-knee is the minor part of the affection.

perpendicularly, they remain of the same length antero-posteriorly; therefore when the patient bends the knee the posterior surfaces of the condyles present in a horizontal plane towards the articular facets of the tibia; but when the patient assumes the erect position, or extends the knee, the lower ends of both condyles impinge upon the tibia. Now, however, owing to the deficiency in depth of the outer condyle, the plane of the articular surfaces *becomes* oblique, the internal part being depressed and the external part elevated, the tibia is forced to resume the position of abduction, and genu-valgum is at once reproduced. (See fig. 16.)

We have already shown that in the young, if the knee joint be extended by the hands of the surgeon in the manner described (pp. 27–29), the distortion does not return, so long as the surgeon holds the limb straight. In the section on treatment it will be fully shown that, whether it be by instrumental means or by supra-condylar osteotomy, the cure of in-knee can best be effected by working upon the same lines.

Mikulicz has strongly directed attention to the frequently slender conformation of the shaft of the bones in genu-valgum, as he says, erroneously we believe, from rachitis, amounting frequently to a reduction of one-fourth of their diameter. A still greater reduction of diameter may be pronounced to exist from clinical examination in paralytic cases, which, as elsewhere stated, often exhibit considerable genu-valgum. We do not know of any post-mortem examination of a recognised long-paralysed limb from infancy affected with knock-knee.

Possibly rachitic bones are sometimes slender; but our experience, derived from clinical observation and anatomical sources, is that rachitic bones have not only increased hardness (eburnation), but often increased bulk. Bearing in mind that the bones of the normal skeleton vary in bulk, and that rachitic subjects are often more or less dwarfed,

we should, when determining the slenderness, or the contrary, of rachitic bones, compare them with the bones of persons who have arrived at a similar age in ordinary good health, but who are of short stature. This is not the place to enlarge on the varieties of the condition and size of the bones under different circumstances of human development; but we may remark that the subjects of asphyxia neonatorum have remarkably slight and fragile bones, and often suffer from knock-knee.

We cannot avoid the belief that so able an investigator as Mikulicz has been misled on this point of bone-wasting in rickets, through his not having been aware that genu-valgum may occur from causes independent of rickets. Mikulicz has from this cause misled so able a surgeon as Macewen. Mikulicz has, if we mistake not, in his table of cases, included those of atonic non-rachitic origin who had died from phthisis, and probably instances of those which appear to have had their origin in infantile paralysis. Such errors may readily arise when acquaintance with the cases is only made in the anatomical department, and not conjointly with clinical examination of the earliest stage in young infants, as well as in adolescents and adults. Mikulicz acknowledges the existence of enlargement and flattening of the articular *surface* of the external condyle as a matter of secondary importance, explained by the preceding relative or absolute statical disturbance through over-loading.

Our observation of the effects of treatment (Diag., p. 27), whether it be by means of instruments alone, or with the aid of supra-condylar osteotomy, shows that the anatomical changes of the external condylar side of the joint are of primary importance. Associated with these changes Mikulicz found the articular *cartilage* of the external condyle and the corresponding articular cartilage of the tibia more or less thickened, sometimes to the extent of 6 or 7 milli-

metres, whilst over the internal condyle the cartilage was found to be particularly thin and altered in its microscropical appearance, so that he lays down the thesis that the *cartilages* of the knee joint on the *external* over-loaded half of the articular surfaces are in a state of hypertrophy, whilst, on the contrary, the internal unloaded half of the cartilages is in a state of atrophy. This abnormal change of cartilage is in accordance with the knowledge obtained from other sources,* that cartilage wastes where it ceases to be in normal contact with another cartilage, so that it ceases to be exposed to normal pressure.

Mikulicz states that he sometimes observed traces of arthritis deformans in the outer half of the articular surfaces, disappearance of the previously thickened cartilage, erosion of the bones, and cauliflower osteophytic formations, such as are represented elsewhere. (See fig. 13, p. 44, from Sandifort.) It is evident from these remarks by Mikulicz, on signs of rheumatism found by him in anatomical inspections of genu-valgum, that he was not aware that rheumatism is frequently a *primary* source of knee weakness and genu-valgum, just as atonic, rickety, paralytic and other disorders may be primary causes of the same distortion (p. 8).

Mikulicz found that the external facet of the patella had shared the fate of the external condyle, as well as the external articular surface of the tibia. The external articular surface of the patella and the corresponding articular surface of the external condyle "were much changed from exposure to the enormous pressure exercised by the quadriceps femoris."

In regard to the condition of the ligaments in genu-valgum he found no striking changes; the external lateral was sometimes shortened, and the internal lateral was some-

* C. Reyher: 'Ueber die Veränderungen der Gelenke bei dauernde Ruhe, Deutsche Zeitschrift für Chirurgie,' iii. 159, circa 1878.

times thickened and unusually tense, but not elongated. He remarks: "This could not be otherwise, for in knock-knee, as a rule, when the knee is extended, it does not hang loosely or wobble about." Mikulicz cannot have studied the distortion in infants and very young children, for the "wobbling" of the joint within the range of a straight limb to a knock-knee is a constant remarkable feature in the early stages of the atonic form (see p. 27) in young children.

He and Volkmann* confirm our statements† as regards the muscles and tendons, that their contraction is of secondary importance, and is caused by the approximation of their points of insertion; the main resisting muscle being the biceps. Guérin regards "*rétraction musculaire*" as the primary cause.

We have met with a few cases of complete luxation of the patella behind the external condyle; partial luxation is more common. For its effect in increasing the difficulty of cure by instrumental treatment, see section on treatment of genu-valgum. Commonly the semiluxation of the patella is of gradual origin, the wasting of the external condyle gradually permitting the external portion of the quadriceps to draw the patella to the outside. The semiluxation increases with advancing age, and increase of the distortion. Occasionally the partial luxation, like the partial genu-valgum itself, is suddenly converted into a full one, through a fall, or a violent effort made to prevent falling. It should be remarked that when even one limb only is affected with genu-valgum falls are very common, probably because one sound limb enables a boy to be venturesome. We do not remember ever seeing luxation of patella in a female.

Mikulicz (p. 624), after reviewing the post-mortem appearances, turns to the constitutional condition of the

* *Op. cit.*

† Lectures in 'Lancet,' 1842-3. 'Treatise on Deformities,' 1853.

individual, as one of powerful etiological influence in producing genu-valgum. He notes the fact, well known to orthopædic practitioners, that sometimes when adolescents affected with genu-valgum, or with flat-foot, stand upright, with the hands hanging free by the side, both hands and feet assume a cyanotic hue, which may extend some distance up the arms and legs. This symptom points, in our opinion, to some abnormal state of the general vascular system (weak heart and weak blood-vessels), which is connected with the deficient energy of the organic muscular system. He refrains from venturing upon a distinct hypothesis on the subject. He connects the cyanotic extremities with rachitis.* Our belief is that we have only, or more often, observed it in non-rachitic cases,—chiefly in adolescents, boys and girls of low tone, of so-called heavy lymphatic temperament, with feebly acting heart, and undue liability to chilblains. His remark reminds us that in the feebly developed children, born with cyanosis from congenitally imperfect hearts, we have sometimes observed genu-valgum from the attendant voluntary muscular and ligamentous weakness.

It has been already stated that the grosser features of genu-valgoid distortion accompanying protracted knee disease from injury or inflammation, regarded in their mechanical aspect, are similar to those of ordinary genu-valgum. In the annexed figure (fig. 24) it is obvious that, when during the stage of effusion the fibrous structures of the knee were weakened and elongated, the joint was at the mercy of the femoral muscles, especially of the biceps, and that a series of mechanical changes, resembling those occurring in ordinary genu-valgum, were brought about. Commonly, however, knee disease distortion differs from

* The reader needs to bear in mind that Mikulicz has written throughout under the impression that only one form of in-knee exists, and has, therefore, mixed together as belonging to one single form of distortion the phenomena observable in the different forms.

ordinary genu-valgum by flexion preponderating over inversion and abduction. In this instance the flexion was of small amount. Until we drew attention to this subject surgeons were not accustomed to approach the study of

FIG. 24.

*Genu-valgoid distortion from destructive knee disease with incomplete ankylosis, knee inversion and leg abduction, with outward rotation of tibia and fibula; viewed from the antero-external aspect:* (*e c, e c*) *external surface of the condyles of the thigh bone, presenting naturally;* (*f*) *the proper anterior surface of the fibula, and* (*t*) *proper anterior surface of tibia, presenting outwardly;* (*p*) *the patella, situated diagonally between the front of the external condyle and the epiphysis tibiæ;* (*a*) *fibrous bands of adhesion between patella and condyles and tibia.—From preparation F. c. 33 in London Hospital Museum. Reproduced from 'Little on Ankylosis,' 1843.*

knee disease from the point of view of future probable deformity (p. 36).

Nearly the same state of things is shown in fig. 25, from a case of complete ankylosis of the knee, from an anatomical preparation in the London Hospital Museum. Reprinted from 'Dr. Little on Ankylosis,' 1843.

Fig. 25.

Fig. 26.

*Genu-valgum from strumous disease; seen from in front.*

The same process of distortion is seen in fig. 26, drawn from the living. There is valgoid deformity of the knee, with some contraction in the direction of flexion from strumous synovitis. The abduction of the tibia amounts to about 30°. Reprinted from 'Little on Ankylosis,' 1843.

The history of chronic rheumatic in-knee would be incomplete without some further reference to the final results which occur when the progress of the deformity has not

been arrested by treatment. This is well shown in the annexed figure (fig. 27), where abduction, flexion and rotation

FIG. 27.

*(a) The upper extremity of tibia, which, instead of presenting two concavities for the reception of the condyles, is rounded, like the head of the humerus, irregular on the surface, in part divested of normal cartilage, and elsewhere of unusual hardness (eburnation), and corresponds in size with (c), a large excavation formed at the expense of the external condyle. The external condyle has*

*entirely disappeared, from the combined operation of pressure, friction, and absorption; (b) the internal condyle, not articulating with any part of the tibia; (d d) the fibula, on which two enlargements or nodes are visible; (e e e e) pedunculated fibro-cartilaginous growths within the articulation; (f) the patella, suspended by the thickened and indurated capsular ligament, and by the ligamentum patellæ. The patella is irregular on the surface, and the investing cartilage has lost the natural opalescent appearance, alterations evidently due to the bone having ceased to perform the function of gliding over the space between the condyles. The letters (g g) indicate firm membranous adhesions; (h) upper part of the shaft of tibia. It will be remarked that the proper anterior surfaces of the tibia and fibula present externally, these bones having undergone outward rotation on their perpendicular and transverse axes, the permanently contracted condition of the biceps muscle having maintained the displacement. The subject from which the drawing is taken is an elderly female, who had been thus deformed many years: both knees were similarly affected.—The preparations are preserved in the London Hospital Museum. From 'Little on Ankylosis,' 1843.*

outwards of the leg have reached their maximum, the external condyle having been almost entirely destroyed.

Enough has been said to prove that in the several forms and subforms of genu-valgum, resulting from different diseased actions, the point on which the progress of distortion may be said mainly to turn is undue contact of the external condyle with the opposing part of the tibia, and consequent arrested development or deterioration of these parts. The identity of distortion and mechanical changes is undoubtedly due to the identity of mechanically acting forces. The reader may be reminded that the influence of gravity has come into operation, because in long-standing chronic disease of the knee, although the patient is confined and much debarred from exercise, he is, during the intervals of amelioration accompanying chronic disease, tempted to make some imperfect use of the limb.

There remains a consideration in the pathology of atonic in-knee to which we have not alluded, *viz.*, the influence of the cerebro-spinal system in its production. We have traced in-knee to insufficient nutrition of the fibrous tissues (p. 14), as from the want of breast-milk, or improper diet, and too

watery a diet. We should be led too far into the domain of general pathology if we entered fully upon the enquiry whether the insufficient and morbid nutrition of fibrous structures and muscles were solely owing to the deficiency of the blood in plastic materials, or whether the weakened tissues were influenced indirectly through the nervous centres. A not uncommon co-existing symptom in children affected with atonic in-knee, at an age when the sphincters are usually in good condition, is inability to duly hold the urine by day or night. This symptom points to origin in disorder of the nervous centre; but we may content ourselves with expressing the opinion that the insufficient nutrition acts simultaneously upon the fibrous tissues and the nerve elements of the central organs of the nervous system; whilst the fibrous tissues during their development suffer directly from want of pabulum, any simultaneous, insufficient, imperfect building up, development and enfeebling of the nerve centres, cannot fail to react injuriously upon the organic strength of the peripheral structures in general.

Some of the conclusions arrived at in this section are that the varieties of in-knee are clearly separable and distinguishable from one another; that *enlargement* of the internal condyle is not pathognomonic of any form of in-knee; that the essentially most constantly damaged parts of the joint are the external condylar part and the external articular portion of the tibia; and further, that in all the forms of in-knee the conditions present at any stage vary in accordance with, and are dependent upon, (1) the nature of the primary causes of the distortion, and (2) the degree of influence of gravity to which the joint has been exposed.

By hand-fed infants (p. 9) are meant such as have been mainly fed upon cow's milk, diluted by the nurse to the extent of from one to two parts out of four with water,—

and which, even in the present day, in some districts, notwithstanding legislation against adulteration, has already been diluted,—or such infants as have been reared upon Swiss or condensed milks, or various advertised artificial infant foods, to which cane or other saccharine matter, and other ingredients, have been added in large proportion. These usurp the place of proper and more nutritious ingredients derived from milk. Other hand-fed infants are often subjected to the ingestion of smaller or larger quantities of various farinaceous substances at an early age, when the digestive organs are fitted only to deal with the duly liquified animal flesh substance which we term milk. Those infants, also, who have been partially nursed upon breast-milk, and are therefore more favourably circumstanced than wholly hand-fed infants, do nevertheless suffer from delayed independent walking, and often present in-knee. In short, a too watery diet, and one composed of substances indigestible and unassimilable at the age when administered, whether it be compounded of beef-tea, animal and vegetable solids, farinacea and frumentacea, are all capable of engendering the infantile debility, apt to terminate in knock-knee, and other forms of weakness and distortion.* We very rarely witness a trace of these distortions in children nursed entirely for one year upon breast-milk, yielded in sufficient

* We know that artificial and preserved foods for infants may not only prevent death from starvation, but that they also duly increase the length and weight. Despite the labours of chemists and manufacturers they are inferior, however, to pure *fresh* milk of animals, for distortions from badly-knit joints most often occur in infants and adolescents brought up upon them. The supply of *fresh* milk for the infant population is increasingly difficult. Might not something be done by the healthy adults who are able to provide themselves with other forms of animal food besides milk, so as to leave a larger share of it to those to whom it is indispensable? Dr. Thomas, of New York, has shown the innocuousness, or rather the nutritive agency, of *new* milk injected into the human veins, and the poisonous property of comparatively stale milk. His experience confirms the wisdom of those nurses who *scald* milk as soon as it comes into their possession.

quantity by a healthy mother or nurse, or who have been gradually introduced to independent feeding, not before the sixth or eighth month of life. Over-fed infants, the excess consisting of unsuitable food, may lead, by the food being imperfectly digestible and unassimilable, to the same result as watery insufficiency of food, *viz.*, alimentary disorders, anæmia, bronchitis, and debility. Even young children who, despite of artificial feeding by cow's milk *in excess*, have apparently passed unscathed through the perilous first year of existence, and have fattened upon it, sometimes to the presenting an unusual and unnatural obesity, sometimes break down with in-knees during their second or third year, after having walked for three or four months without signs of weakness. Here the direct cause of the distortion is excess of weight, compared with the normal strength of the fibrous structures at the age in question. The proof of the sufficiency of the cause has been furnished by the prompt recovery from distortion which resulted from reduction of weight by "dieting," with comparatively little aid from other measures, and the occurrence of the same series of facts in adolescent giants.

A potent aggravating cause of a large proportion of the cases of infantile genu-valgum in large cities is to be found in the relative impurity of the air, which prevents the young child's assimilating organs educing from the nutriment, whatever the nature of the food may be, the healthy blood and stamina, which are more commonly the lot of even the reputed less well-to-do agricultural resident.

Meanwhile, through the greater stimulus to the brain of the two-year old child in cities, owing to the greater number and variety of objects presented to it, the disposition to incessant locomotion of the child in and out of doors is as great in towns, if not even greater. We believe that the space of two or three hours passed on the common, in the country lane, in the wood, from the more soothing and

satisfying influences of the child's surroundings,—gathering flowers, *sitting down* making daisy chains or mud heaps,—the young child's mind and body are less incessantly in activity than those of the town child. Hence the relative amount of locomotive work done by the town child with his feebler tissues, regarded as a factor in the production of genu-valgum, is greater than in the country child, with his less exciting life, his heartier digestion and assimilation, and consequent robuster tissues. A relatively too great locomotive activity in town children should, then, be reckoned as one of the determining causes of in-knee and allied distortions, after the first and second years of life.

It appears probable, also, that children of those classes of society whose life is passed, either from choice or necessity, in a continual round of excessive cerebro-spinal and intellectual activity, derive, either from inherited influences or from the influence of their surroundings, a precocity of intelligence and a neurosis of restlessness, caused by the central organs of the nervous system receiving more than their full share of blood materials. Consequent upon this precocious stimulation of the nervous system there may ensue or arise a proportionate impoverishment, arrested development, loss of tone and stamina in the active and passive locomotive organs.

There is reason to believe that the proportion of atonic disorders in general has increased with increase of luxury and population. As regards the probable increase of weak or in-knees, it is probable that formerly the young child when first "running alone" was restrained by leading strings or the go-cart, and was less constantly attended by helps and nurses, who continually lead the child to fresh objects of interest and excitement. Yet the expression of "weak-kneed" has been long enough used metaphorically to signify a peculiar indication of general weakness and unfitness of character, and suggests that our atonic physical

in-knee, with its attendant liability in the individual to fall about, may have been long popularly known as a hindrance to reaching the goal. The metaphorical use of the expression "weak-kneed" may also have been suggested by the bent, tottering knees of the aged.*

An indirect, if not also a direct, hereditary influence in the production of *non-congenital* in-knee may sometimes be recognised. We have often been told by parents that one or more of the relatives, or the husband or the wife, have been similarly affected. Often it is found when the first-born child, aged four or five, is brought for advice, that two or three younger brothers and sisters have the same complaint in a lesser degree.

When weak in-ankle and weak in-knee co-exist in the same individual (p. 15) observers have differed as to which of these distortions preceded the other. From analogy with other forms of disorder, and from the statements of patients and nurses, we are of opinion that the ankle first suffers, or that they simultaneously originate. The feet being more exposed to view, the weak ankle is more likely to attract notice.

In atonic in-knee,† as before observed, and as shown in

* Dr. Johnson employs the terms "in-kneed" and "knock-kneed" to express genu-valgum and genu-varum. We have (p. 1) given our reason for preferring "in-knee" to "knock-knee," and see less reason for using Latin terms when we possess longer used and more expressive English ones.

† We prefer the term atonic to that which has been given to it by Volkmann, *viz.*, idiopathic, because it defines the nature of the case, and because atonic in-knee, as we believe we shall have proved, springs from a more or less general atonic condition of the system, as shown by the frequent co-existence of atonic flat-foot, atonic scoliosis, and even other atonic affections (p. 15) with it. Atonic in-knee is no more idiopathic, peculiar, or standing alone or by itself, than rickety in-knee is idiopathic. On the contrary, both atonic and rachitic in-knee are instances of what some pathologists have described as deuteropathic affections, *i. e.*, products of another disorder, atonic in-knee of an atonic condition of system, and rachitic in-knee of a rickety state of system (rachitis).

figs. 15, 28, no positive signs of rickets can be discovered, unless we were prepared to regard the weakness in question as the first stage of that disease (see p. 41). Dentition may be behindhand. At twelve or fourteen months old the child may have cut only two or four teeth, but these are apparently of good texture, as will also be the second set of teeth if no rickets, syphilis, or mercurial poisoning have been present. The child may show active desire to use the limbs, but may not have sufficient strength to raise himself unaided to his feet. If able to effect spontaneous locomotion, he often does it with the aid of articles of furniture. Weakness in the loins may be suspected, but distinct too great hollowness of this part (anterior lumbar curvature of spine, lordosis) is absent. The abdomen may be rather large, as it commonly is in all children of the age, but the disproportionate tumidity of distinct rickets is absent. There is no discoverable enlargement at the place of junction of the ribs with their cartilages, no enlargement of the joints of the extremities, no flattening of the ribs and diminution of chest capacity, and no curvatures of the shafts of the long bones. The head is well shaped, and the face well proportioned to the cranium.

FIG. 28.

*Atonic in-knees, slight; the symmetry as regards contour, stoutness, and length, excludes the notion of rickets. Compare the more severe rickety knees,* fig. 4, *and their want of symmetry. The posterior view of this case is shown at* fig. 12.

It is well known that amongst certain oriental nations the joints are so ill-knit that the finger joints are unduly loose compared with the corresponding joints of Europeans, so that the fore finger, at the metacarpo-phalangeal joint, can be extended to such an extent that it can be placed at a right angle to the back of the hand, and can sometimes be so far doubled back as almost to touch the back of the hand. We have observed this condition of things in the few Hindoos whom we have met with in this country. We have seen the same in Eurasians, and even in the case of children born in the tropics of European parents. We have observed the same in the cases of children born in this country of European parents, who have never resided in tropical climates, but who have been reared with little or no breast-milk.

Now the want of tone in such inhabitants of tropical and semi-tropical countries, as is evinced by such marked ill-knit joints compared to those of Europeans, is probably akin to that want of tone met with by us in those children of European parents who have been brought up by artificial feeding instead of by breast-milk, and which gives rise here to such distortions as atonic in-knee, ordinary non-rachitic twisting of the spine—scoliosis, miscalled lateral spinal curvature, non-rachitic atonic in-ankle—commonly called weak ankle, and other atonic disorders. (See p. 14.)

We should be led too far if we entered fully into a consideration of the probable causes of the state of things—atony of the fibrous structures compared with Europeans—which appears to be the *normal* state of certain oriental nations, and which permits such laxity of joints as those to which we have directed attention. We content ourselves with the statement that climate, diet and social habits will probably on further investigation be found to explain the condition of things. It appears to us a very remarkable fact that less than a single generation of exposure to the above

tropical influences should suffice, as we have noticed, to produce in Europeans the ill-knit condition of joints almost peculiar to orientals. We look for information on this subject to the British physicians who have had a professional life-long experience in tropical and semi-tropical countries, especially those who have so ably represented our profession in India, the Straits, and China. We have had under our care many children of young British mothers presenting the atonic condition in question, including in-knee distortion,—mothers who had spent very few years in India, but whose parents had not lived in hot countries. Sometimes the father and grandfather had been subjected to tropical influences; in these instances, therefore, it is presumed that paternal influence may have been more predominant in the links of causation, as far as climate was concerned. In several children born in India of European parents, affected with atonic knee or foot distortion, the acknowledged total or partial want of breast-milk was to us sufficient explanation. In others the mothers were said to have nursed their children, but often it appeared, as in the case of many English born children, that the nursing had been inefficient, or only partial.

We are commonly told by Eastern and African tropical and semi-tropical travellers that distortions of all kinds are rare among the natives of hot countries. We should like to learn the experience of our recent great Indian medical authorities, who have devoted themselves to the study of the physical and sanitary welfare of the natives. Rarity of distortion has been in part accounted for by the habit of destroying the young infant so affected immediately after birth. This circumstance may explain the absence of congenital distortions noticed by the traveller. If an habitual laxity of joints prevail in hot countries, we should expect the atonic distortions, of which we are treating in this work, to be numerous. Possibly a life spent practically in the

open air day and night for the greater part of the year may tend to neutralise the disorder. The brain and habits of the young amongst the natives of hot countries may be less energetic, and the exciting objects fewer. The habit of dispensing with chairs and tables, and of passing much time on the ground or in sleep, may diminish in hot countries the too early or too constant use of the lower limbs, which the English child indulges in, and reduce the influence of statical causes of distortion.

Referring to the adolescent atonic form, we stated in 1842 (*op. cit.*) that this distortion "is frequently witnessed in youths who have been too early employed at occupations requiring much standing or walking, as in shop and errand boys, printers, smiths, &c. Constant standing in one position is more prejudicial than even undue walking. Occasionally it arises from, or rather it is first noticed after, a sprain, a fall, or other accidental injury of the knee. Genu-valgum may exist and occasion an outward yielding of the member." See fig. 29.

Fig. 29.

*In-knee, and hyper-extension of right knee, with outward curvature of left limb. From Macewen, 'On Osteotomy.'*

We have no descriptive evidence whether this case exhibited other signs of rickets besides distortion. From the drawing (fig. 29) we should consider the case not to be rachitic, and that the left limb represents accommodative curvature of thigh, knee and leg, in consequence of the considerable shortening of the right limb produced by in-knee and hyper-extension of it, and probably from pressure of the right against its fellow.

Many cases of palpable but comparatively slight infantile

weakness of the lower extremities are met with, in which the most experienced physician or surgeon has, at first sight, reason to doubt whether he has to do with (1) slight infantile paralysis, (2) with debility from insufficient nutrition and anæmia, or (3) with a slight amount of rickets. In such cases the weakness, in whichever of the above-mentioned three modes it may have originated, affects equally all the fibrous and muscular structures of the thighs; and the knee joints, becoming therefore less firmly braced by them than is natural, yield to the superincumbent weight of the head, upper extremities, and trunk, in the manner before described.

We have seen many cases which have occurred at different ages between four and fourteen, in both sexes, in children who were reported to have been perfectly sound and strong previous to three or four weeks' confinement to bed or room, with scarlet or other fevers, followed by much general bodily weakness. The non-existence of distortion before the illness, and the gradual occurrence of it some weeks or months afterwards, prove that the child had resumed active life and locomotion before strength had been restored. Bearing in mind the influence of rapid growth, it is not surprising that a distortion identical with that which occurs in infancy should be developed at the intermediate period mentioned. The facts suggest the importance of good nutrition, early hours, and avoidance of too strenuous and too early application to mental and bodily labour and exercises in fast-growing adolescents, especially after any serious illness. It is rare to see curvature of long bones in any other than rachitic cases.

In childhood and adolescence, as in young infants deprived of breast milk, a hereditary or acquired predisposition to this particular weakness, denoted by want of robust appetite and active digestion, may have existed, so that they have broken down upon the application of exciting causes, such as late hours and undue toil, which may be well borne by those of robust constitutions.

In the metropolis, and probably in all cities, a large proportion of infants, belonging even to the well fed, well clothed, well warmed, yet often insufficiently aired, classes of society, who are the subjects of consultation because of their inability to walk properly alone at the usual age, are affected with debility, showing itself in the relaxed condition of the tissues in general, and especially of the fibrous and muscular ones. But amongst the well-to-do classes in-knee rarely originates after childhood, except through debility induced by fevers.

## ON THE SYMPTOMS AND DIAGNOSIS OF ATONIC, RACHITIC, SPASTIC, PARALYTIC, STRUMOUS, AND RHEUMATIC IN-KNEE.

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We are prepared to find that objection will be made to our entire separation of atonic knock-knee and flat-foot from rachitis, and it may be maintained that reduced tone of muscles and of fibrous structures is a *stage* of rickets. We have shown (pp. 31–40) sufficient reasons against the exclusively rachitic view, and in favour of diminished tone, until morbid anatomy observations shall have decided against it. Occasionally, when a child having previously walked is "taken off his legs," or having reached the age when he should walk does not walk, it is in the earliest stage difficult to distinguish between the incubatory softening stage of rickets about to lead to distortion, if not interrupted, and slight paralysis from spinal causes.

Rachitis, owing to increasing means of differentiating it from other forms of bone deterioration, is becoming better understood. A positive proof that the atonic condition of the fibrous (ligamentous and muscular) structures is a different disordered condition from rickets, appears to be afforded by the fact that the in-knee commonly called statical (as distinct from rachitic), and which we prefer to call atonic, *originates* when the growth is most rapid, not only in early infancy and childhood at the age and during the years in which rickets invariably begins and ends (distortion perhaps remaining unless counteracted by art), but may originate also between the ages of five and twelve, and

especially often during the second fast-growing period which precedes puberty (age twelve to sixteen or seventeen), when rachitis does not originate. We believe that there is not a single *fact* on record to show that any symptom or sign of rickets affecting the bones (softening and subsequent eburnation) or other parts of the frame was ever observed to originate within those years. We would enquire, Who has ever seen a case of rickets, such as figs. 32, 33, and 34, originate at any other period than early childhood? There have been plenty of in-knees without bone softening and curvature, such as fig. 5, seen to originate after childhood, but these we have shown are non-rachitic. We are aware that several most able men believe they have seen rickets originate during adolescence, because they have seen statical non-rachitic knock-knee produced at that period, but they have assuredly been mistaken.

We consider that no pathologist will deny that unequivocal rachitis exhibits distinct stages, that these stages run a definite course as to time and as to the nature of the bone and constitutional changes; and the osseous system, which has once traversed the ordinary rachitic stages, has never been known to traverse these stages a second time, differing in this respect from somewhat analogous bone changes which occur in another disorder, scorbutus.

Another fact, which confirms the identity of the non-rachitic genu-valgum of early infancy, and that which begins at impending adolescence, is that a child may be practically cured of this form of knock-knee in infancy, and yet if subjected to the causes of non-rachitic knock-knee (pp. 8, 65), during the extra rapid growth of approaching adolescence, the complaint may return, whereas no one has ever seen a once softened and curved, then afterwards straightened and eburnated rickety bone, soften and bend a second time.

It should be noted that atonic knock-knee, as we have

shown, may originate during adolescence, and that atonic in-knee, if existing before adolescence, and rachitic in-knee may become greatly, and often very suddenly, aggravated by undue standing and walking, and weight carrying, at that age. The changes at this age are at the joints only in atonic knock-knee, and even in rachitic cases the aggravation is sometimes more in the joints than in the bones. Although eburnated bones are doubtless less inclined to bend than normally ossified bones of that age, yet eburnated and much distorted bones may not be able to resist further bending at any age when exposed to the influence of gravity so disadvantageously applied, as in the case of individuals whose bones are already curved having to bear the burden of relatively heavy weights and over-standing and walking. Such persons can only be correctly described, pathologically and symptomatically, as persons affected with rickety *distortion* caused by rickets in early childhood, now, *i. e.*, in adolescence, becoming aggravated by statical influences. They cannot be correctly termed the subjects of rickets (cachexia, or dyscrasia rachitica), for that *disease* subsided in childhood, certainly before the age of five or six years. Observation shows that bones which have once reached the stage of eburnation do not, as we have already said, again soften; the increase of deformity during adolescence mainly, if not exclusively, depending upon yielding at the joints, and not in the already curved shafts of the bones. The sudden appearance of atonic knock-knee, or of comparatively sudden aggravation of pre-existing slight rachitic distortion, have misled physicians to the belief that rickets may originate in late childhood and adolescence.

Severe rickets affords the most intractable of the causes of in-knee, when the constitutional disorder and the local condition have been neglected in the early stage. A state of more or less complete rachitism is a frequent cause also of the inability of infants to stand or run properly

alone at the ordinary age when unaided proper locomotion is effected, say from the tenth to the fifteenth month. It is unnecessary in this paper to enter fully into the pathology of rickets, but we may be permitted to reprint some remarks, published by one of us in a course of lectures in the 'Lancet,' in 1842–3, introductory to the subject of in-knee, and its commonly associated complaint, flat-foot. "In relation to distortions the important feature of rickets is that of softening the bony frame-work of the system; hence a sinking of certain parts beneath the superincumbent weight, and a liability to alteration from the natural shape through the action of the muscles attached to them. . . . . Rickets is not solely a disease of the osseous system, but its effects are in this part more obvious, and therefore have been longer noticed. Our own opinion is that every tissue of the frame is involved in the loss of *tone* and firmness,—the bones, the ligaments, the involuntary and voluntary muscles and their appendages the membranes, glandular (the chylopoietic) organs, and the nervous system. The precursory signs of rickety distortions, consisting of slightly enlarged head, weakness of loins, pallid face, flabby though bulky limbs, tardy dentition, tumid abdomen, with continued liability to bronchial, gastric and intestinal derangements, manifest themselves from the sixth to the twefth month. Soon the wrists begin to enlarge (add here the chondro-costal junctions to swell), the ribs to flatten, the bones of the lower extremities to be slightly curved, and the child remains incapable of standing; deformity is already apparent. In a more advanced stage more numerous articulations become distorted, the inner ankles sink beneath the weight of the body, the knees 'knock' together, the thigh and leg bones curve, flexion of the pelvis upon the thighs, and curvature of the lumbar vertebræ forwards (lordosis), ensue."

It will facilitate the student's diagnosis between the atonic and rickety in-knee if in this place we picture the

most extreme form of rickets; for when acquainted with the strong features of well-marked rickets he may be enabled to discover one or more of its acknowledged signs. Be the traces even slight, he will be justified in classing the in-knee as of rickety origin, whether or no the actual rickety dyscrasia have been recovered from, and distortion only remain.

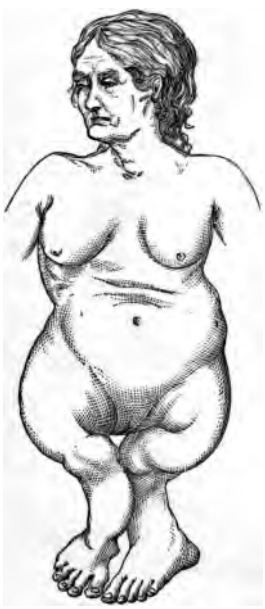
Fig. 30.

*Extreme in-knee, with bone curvatures, rachitic, and disproportionate growth of parts in an adolescent, aged seventeen, the whole height being little more than four times the length of the head. (From Little, on 'Deformities of the Human Frame,' 1853.)*

Two facts respecting rachitis have been known to clinical observers from the time of Glisson to the present day. (1) That the tendency of rickets is to shorten the stature, to give to the head a disproportionate largeness, to narrow and flatten the chest from side to side, to arch the clavicles upwards and forwards, to produce protuberance of the belly, excessive length of the arms, disproportionate shortness of the lower limbs, and curvatures of the long bones, especially in the legs, seldom without some in-knee deviation. The whole of these changes are well shown in fig. 30. (2) That rickets commonly affects the bones of the lower extremities to a greater degree than those of the upper part of the trunk. It is quite certain that rachitic *distortions* are more frequent and more considerable in the lower extremities than in the upper; yet it might be that rickety *distortions*

impress the senses and mind of the observer to a greater extent than the constitutional and more concealed phenomena of the disease, and therefore might have led to an erroneous conclusion that rachitism may affect earlier, and to a greater degree, the bones of the lower extremities than those of the upper.

FIG. 31.



*Extreme rachitic arrested development of the lower extremities in a female.**

Our experience and belief is that the statements are facts. We have only to look at an extreme subject of rachitis who has completed growth to note the disproportionate length of the trunk compared with the extremities, and that often the lower limbs alone are appreciably affected with deformity.

Annexed is a figure, from Bouvier (*op. cit.*), of a female, aged sixty-nine, with extreme rickety distortion of the lower extremities, and considerable rachitic spinal curvature, whose entire height did not exceed a metre; but for the spinal curvature it would have been a few inches greater. The view of such a case suggests the belief that this individual, having being seized with rachitis at a very early period of existence, probably intra-uterine, has, as regards the proportionate size of the upper extremities and trunk

* When the like of the above is extruded from the uterus before its time our German friends name it, "mikromelie;" or when the uterine product exhibits the extreme of rachitic mikromelie they designate it, "phokomelie." If the product should survive to seventy years the term myle, mola, or mole, would not be very applicable. See Urtel: 'Ueber Rachitis Congenita,' Halle, 1873.

and the lower extremities, remained nearly the same as at the commencement of the disease. In fact the individual may be regarded as an example of arrested development, especially of the lower extremities, from rachitis. The earlier and more complete the rickets, the greater the arrest of development and the shorter the lower extremities will be in the adult.

We have shown (pp. 16, 87) how considerable in the healthy infant is the growth of the bones of the lower extremities during the earliest months of life, whereby the disproportionate shortness of these parts at birth is removed. If the infant comes into the world with hereditary rachitis, or with a predisposition to it, acquired at the period of impregnation of the ovum, or imbibed during gestation, the onset of a disease, one of the essential characters of which is to prevent healthy bone development, is likely to be first manifested in the parts of the osseous system,—the bones of the lower extremities,—which in the human fœtus are comparatively small before birth, and which in the norm undergo a remarkable increase of growth during the first few months of life. It is known that at birth the vertebral column, and consequently the trunk, is naturally long compared with the lower extremities. It is also known that the vertebræ are less apt to be affected with rachitic softening and subsequent hardening (eburnation) than the "long" bones of the lower extremities.

Despite the oft-reported artificial production of rachitis in domestic animals, we consider it doubtful whether this disease is ever the result of the operation of its predisposing and determining causes in a single generation, whether it be not always hereditary, whether it is not as much a specific disease as syphilis, cancer, variola, or scarlet fever. Two or more children of the same parents affected with rachitic in-knee are often seen; but amongst well-to-do people, whether brought up at the breast or spoon-fed, we have oftener seen,

we believe, a single distinctly rachitic child in a family where there were several healthy well-grown brothers and sisters, than we have seen a single genu-valgum in a large family from deficient unsuitable feeding, owing to the absence of breast-milk of the mother. The earliest born children of a mother who cannot "nurse" her infant usually suffer oftenest from non-rachitic genu-valgum, whilst our belief is that a single distinctly rachitic young patient has often been one of the later born of a numerous family.

We here append figures (figs. 32 and 33) of the best marked rickety enlargements and curvatures of leg bones,

FIG. 32.

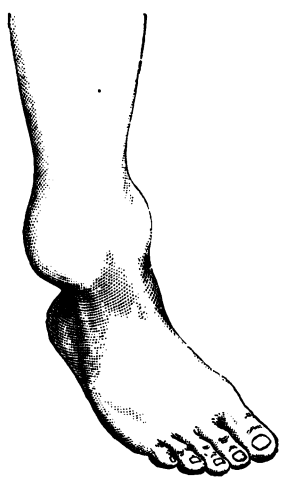
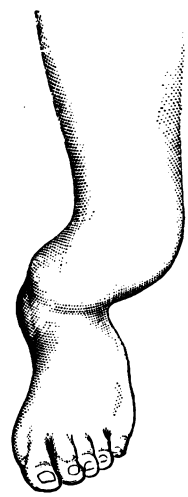


FIG. 33.



FIGS. 32, 33.—*Typical distortion of the epiphysis of the tibia and fibula in rickety distortion often accompanying rachitic in-knee, co-existing with a similar condition of the wrists and fore-arms.*

and of abnormal weakness and hollowness of loins (lordosis), fig. 34, apt to occur in rickety subjects. It should, however, be known that similar hollowness of loins may arise from other local or constitutional states than rickets, namely,

atony of fibrous structures, paralysis of lumbar muscles, and from congenital and acquired luxation of the hip.

Another important and early sign of rickets is afforded by the globular, more or less bead-like swellings formed at the sternal end of the ribs at their junction with the cartilages ("le chapelet rachitique." See Guérin and Bouvier, *op. cit.*). Any trace of such swellings in a case of in-knee proclaims its rachitic character.

FIG. 34.

*Lordosis, believed in this case to be due to atonic relaxation, and not to rickets.*

Nor should examination of the teeth, especially of the second set, be omitted, as these often display the rachitic character of parallel horizontal lines of enamel taking the place of an uniform layer of this hard material, the deficiency being commonly greater at the cutting edge of the tooth than towards its root, and in extreme cases both the sets being extremely deficient in hard matter, and being many of them shed soon after they pierce the gums.

In order to further understand the bearing of these facts upon the diagnosis of non-rachitic from rachitic knock-knee, it will be necessary to dwell for a moment upon the normal condition of the lower limbs during the later months of pregnancy, and the normal development of these parts during the first months and years of life, and compare this normal state of things with the abnormal state of things introduced by the rachitis.

Any surgeon, familiar with the treatment of congenital club-foot during the earliest weeks and months of the child's

life, will have been struck with the fact, already mentioned, that an extemporised splint of any inextensible material fitting during the first fortnight or month becomes uselessly short during the second fortnight or month, and that this experience is repeated every few weeks afterwards; and every nurse takes pleasurable notice of the rapid growth of healthy non-distorted limbs at this period of life.

Every parent with a large family of sons has known too well the economic difficulty of keeping fast-growing boys supplied with trowsers of sufficient length from the age of about thirteen to seventeen, and the physiologist is aware that at this age the previous disproportionate length of the trunk is rapidly balanced by the uncommon rapid development in length of the lower limbs at that age, in order that by the end of adolescence the individual destined to be, say, for example, six feet high, shall measure upwards and downwards from the trochanters each way three feet. Indeed, there seems a time between thirteen and seventeen when the proportions in the length of the trunk and lower extremities are for a time only, even the reverse of the state of things at birth, for at birth the trunk is relatively long compared with the lower extremities, whilst during adolescence the proportions in non-rachitic individuals are apt to be reversed.*

A large and long male infant, the first-born of the family, destined, as the result showed, to be over six feet high when growth was completed, weighed at birth twelve pounds, and measured twenty-two inches in length. At three years old, agreeing with the commonly received opinion that at that age half of the ultimate height would be attained, this child measured something over thirty-six inches, and was seen by one of us on account of the appearance of slight double (atonic) in-knee. During three years,

* See Alexander Shaw: article, "Rickets," 'Holmes's System of Surgery,' 2nd edition.

up to this time, he had grown at an average rate of four inches and two-thirds annually. But as seven inches, one-third of the growth at birth, were probably added to the growth during the first year (see p. 16), the growth during the second and third years amounted to about seven inches in these two years. He became six feet high at twenty-one, and did not cease growing until twenty-three, when he attained the height of six feet one inch and a half. Between the age of three and twenty-one he had only grown thirty-six inches, an average of two inches per annum. As it is certain that he grew rapidly soon after the commencement of adolescence, there were years before adolescence and during the later part of adolescence during which the growth will have been less than two inches yearly. We are without sufficient data for the average growth of healthy boys and girls between the ages of thirteen and seventeen.*

* Since the remarks on the rate of growth in infants (on p. 17) were printed, we have been favoured with the following observation on the growth of a healthy male infant, born in November last, the first child of the marriage, nursed entirely at the mother's breast, and which has had no appreciable health disturbance since birth, *viz.*:—

| | | | |
|---|---|---|---|
| Weight at birth, 5½ lbs. (about) . . . | | Length, 17½ in. | |
| „ „ age of one calendar month, 11 lbs. (accurately weighed) . . . | | „ | 21 „ |
| „ „ age of two calendar months, 12 lbs. 4 oz. (accurately weighed) . . | | „ | 23¾ „ |
| „ „ age of three calendar months, 15 lbs. (accurately weighed) . . . | | „ | 23¾ „ |

It will be interesting and useful if some young obstetricians will accurately weigh and measure a series of infants at regular monthly intervals during the first eighteen months, and subsequently at annual intervals, and note any apparent variations of the rate of growth caused by successive changes of diet, town or country residence, or by illness of any kind. The date of "running alone," also the date of commencement of any illness or distortion, and its duration, would tend to advance the knowledge of the disorders and diseases of childhood. This application of "the numerical method of medicine" would also afford precise data respecting the effect of acute illness and recumbency in accelerating length during advanced childhood and adolescence.

It is certain that the greater number of atonic cases of in-knee arise at the two periods at which the most active physiological evolution of the bones of the lower extremity take place, the first period extending from birth to the age of three or four years, and the second period coinciding with that of puberty (age twelve to seventeen). Rachitic disease, it is equally certain, is confined to the first of these periods, although *distortion* may remain and possibly increase through the influence of gravity (see p. 79). Infantile rachitic curvatures of the lower limbs with in-knee are brought to us at the same period of life as the non-rachitic; but it will be found on investigation that many of these children had signs of rachitis at birth, or very soon afterwards, and were not brought to us for advice until the deformity was more glaring, and the parents had lost the hope of "the child out-growing it."

These observations on growth lead to the last point of distinction between in-knee of simple debility from relative over-exertion in proportion to strength (genu-valgum atonicum, staticum),—which occurs pre-eminently in fully proportioned, long-boned, fast-growing, tall infants and adolescents,—and in-knee from the specific disease, rachitis, which tends to arrest growth, shorten the bones, and present distortion in comparatively short-limbed individuals, consequently of ultimate comparatively short stature, and which begins and ends in infancy, *i. e.*, before the age of five or seven years.

In the diagnosis between rachitic and non-rachitic deformities it may, during infancy, practically suffice to regard as non-rachitic those cases which present no signs of rachitis in other parts of the economy. The first appearance of in-knee during adolescence, say from the twelfth or thirteenth to the sixteenth year, seeing that rachitis never originates during those years, is conclusive evidence that we have to deal with a non-rachitic affection. Macewen and others,

who assert that they have witnessed the origin of rachitis after childhood, have been misled by the *à priori* notion that all cases of knock-knee are due to rachitis. We have never seen rickets and its consequent curvatures, combined with genu-valgum, originate after infancy. We have never even seen a case of rachitis after the age of four or five years, for by that age the natural transition from softening to undue hardening has fully set in. The deformities from curvature of bones and yielding of knee joint may remain, but these are the effects of disease, and not the rachitis itself. We have seen rare cases of mollities and fragilitas ossium originate during later childhood and puberty, but these cases are acknowledged by pathologists to be distinct from rachitis. As far as we have observed these cases have not recovered, have never been succeeded by a stage of eburnation, which, as is well known, is the spontaneous mode of termination of rachitism.

Bouvier (*op. cit.*, p. 314) says: "On est souvent disposé à attribuer à la seule action du poids du corps les courbures des jambes qui affectent des enfants jouissant en apparence, d'une santé florissante. J'ai presque toujours trouvé ches ces enfants quelques traces de rachitisme, le chapelet par exemple. J'en dirai autant des deviations du genou." Bouvier regards the "chapelet rachitique" as the pathognomonic sign of the first stage of rickets. We should place *nodes* at the ends of the bones of the extremities in the same, if not in a higher, rank of signs.

Broca, as quoted by Bouvier, *op. cit.*, p. 292 ('Recherches sur le Rachitisme,' Paris, 1852), says that "toutes choses égales d'ailleurs, le rachitisme affecte principalement, à son début et pendant sa durée, les régions qui offrent la plus grande activité de développement aux époques correspondantes de l'état physiologique tandis que les os dont le plus grand développement est antérieur ou postérieur à l'invasion de la maladie en ressentent moins les effets."

These views of Broca support the opinion of Guérin that the bones of the lower extremities are earlier and more severely affected with rickets after birth than those of the trunk, and that the first signs therefore of rickets would be found in the lower extremities. We have no data as to the rate of growth of the ribs compared with the bones of the lower extremities. From the known capacity of the chest to enter upon the act of respiration immediately after birth, we presume that the ribs like, the vertebral column, are relatively more developed at birth than the lower extremities, so that if rachitis be apt to show itself earliest in those bones which in the norm should be most actively occupied in physiological development, we should expect to find the first signs of rickets in the ankles and legs. By the time, however, children are brought to us we commonly find beads of enlargement on the anterior ends of the ribs, whenever, in a rachitic infant, we look for them.

In diagnosis between non-rachitic in-knee and the rachitic form it is well to remember that the apparent degree of the knee distortion is augmented in rachitic cases by the frequent curving inwards of the femur at its lower third, and of the tibia at its upper two-thirds. These curvatures, if not considered, may lead the surgeon to overestimate the true amount of knee *joint* inversion; for we have shown in the preceding pages that in-knee may exist without curvature of the bones. It may even be safely asserted that the inward inclination of the knee joint itself is greatest in the cases in which no rachitis exists. A glance at fig. 2 and fig. 3, and fig. 15, representing cases of in-knee unconnected with rachitis, is conclusive on this point.

Some modern surgeons, as we have already stated, have wrongly confined the term genu-valgum to rachitic cases. (See p. 20.) If by genu-valgum is meant inward inclination of the knee joint, the term should rather be confined to the non-rachitic forms. Bad cases of rachitic knock-knee,

with curvature of thigh and leg bones, would be more correctly termed rachitic curvatures of those bones with genu-valgum.

Another point of difference between non-rachitic and rachitic cases follows as a consequence of the absence of curvature of bones in the former, namely, that in these, apart from the inversion of the knee joint structures, the contour of the thigh and leg are unaffected: these parts remain as symmetrical as they were before the genu-valgum took place, as may be seen in the reduced copies of outlines of the limbs affected with in-knee, taken some years before the discovery of photography, by passing a pencil around the child's limbs whilst he lay recumbent on a sheet of paper, fig. 11. Fig. 15, copied from Mayer, which was not published in support of my argument, illustrates the same fact. Volkmann (*op. cit.*, p. 720) describes an interesting case of in-knee following some long time after traumatic injury of a limb. We have the photograph of an adult who, after reunion of a fractured tibia and fibula, became affected with considerable in-knee, requiring months of mechanical treatment before it could be securely cured.

Another point of distinction, however, is that non-rachitic in-knee may be cured in the young child in a few weeks or months, whilst the changes required to be effected in the rachitic constitution for its cure, and the arrest and permanent removal of the attendant curvatures of the thigh and leg bones, which so much intensify the genu-valgum, is often a matter of months or years.

However distinctly severed the pathology of ordinary infantile paralysis is from that of rachitis, there is no *à priori* reason why they should not accidentally co-exist. Fig. 35 represents the co-existence of infantile paralysis of lower extremity with slight genu-valgum, without curvature of leg bone. So rare is the co-existence of two distinct

forms of disease in the same individual that we experience difficulty in assigning the true pathology of the case represented (fig. 36). This case stood in Little, 'On Deformities,' 1853, p. 229, as a case of genu-valgum with paralytic varus. At that period we regarded the bone curvature to be due to rickets. We do not remember having met with other cases of paralysis and rickets in conjunction, even if not of simultaneous origin. This case and that copied from Mayer, on page 20 of this work, suggest the thought whether in bone curvature the yielding of the leg beneath the superincumbent weight of the trunk may not often take place at the junction of the upper epiphysis of the tibia with the shaft of the bone. If the case, fig. 36, be not rickety, then, as the paralysis was especially severe in the leg and foot, the attenuated bones of the leg, wasted by the paralytic want of organic nutrition, may have yielded to gravity during the struggles of the individual to effect locomotion upon it.

FIG. 35.

*Slight paralytic right lower extremity, with slight genu-valgum and equino-varus.*

In fig. 37, where the paralytic in-knee is most severe, so much so as to have compelled resort to crutches, although the tibia is extremely slender, there exists no bone curvature, because the effects of gravity could not come into operation.

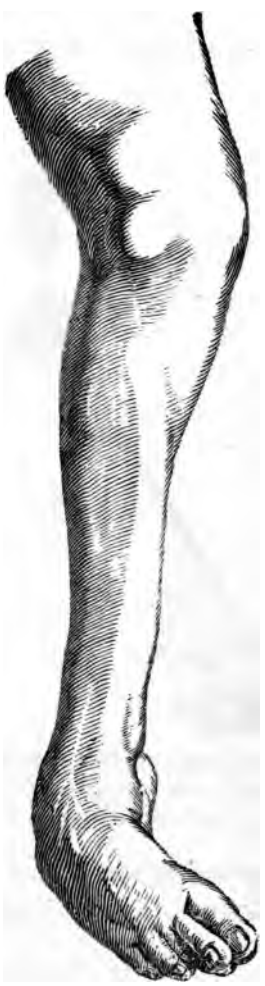
Fig. 38 shows a much greater amount of knee inclination, with considerable knee contraction in the direction of

flexion, in a child affected with very general spastic rigidity and contraction of muscles, following upon *asphyxia neonatorum*, sometimes the result of abnormal parturition.

It will be remarked that in the first of these paralytic cases the in-knee deviation is very slight. The distortion is the natural consequence of the paralysis having been sufficiently severe to interfere greatly with walking. In the ordinary atonic and ordinary rachitic in-knee the volition of the individual, with advancing age, is strong, and prompts to considerable use of the affected limbs, until in fact with great increase of deformity the labour and pain of walking may lead finally to its abandonment. With paralysis of limbs, however, affecting the muscles of both the knee and the leg, any considerable amount of spontaneous locomotion is impossible, especially when the knee has once given way inwards; consequently in paralysis the inward inclination never attains any considerable degree.

The contrary is the case, however, in cases of the lower limbs contracted from spasm, fig. 38. Here the obstacle to

FIG. 36.



*Severe paralysis of lower extremity with slight in-knee deviation, paralytic equino-varus contraction, and slight twist (rachitic? or merely statical?) in the leg bones.*

locomotion is not the weakness of paralysis, but the stiffness, rigidity and contraction of muscles ill co-ordinated, disturbed by choreic irritability,* the knee joints and ankle being brought after a few years into a state of constant contracture, and structural or adapted shortening. In these cases nutrition and growth of muscle are superior to those of the paralysed limb; the patient takes exercise in a peculiar jerky stiff characteristic unsightly manner, yet contrives to take a good deal of it; hence the effect of superincumbent weight is more operative, and leads to a larger amount of in-knee. This kind of lameness and its pathology were discovered by us before 1842. See lectures in the 'Lancet,' 1842-3. Obstetrical Soc. Trans. 1868.

Fig. 37.

*Most severe paralytic genu-valgum, with most severe foot contraction. From Little, 'On Deformities.'*

From the example of the occurrence of distortion in paralytic limbs (see figs. 35, 36, 37), in which the proper antagonism of the several classes of muscles has been annihilated, we know that a particular muscle may obtain a

* Such cases are not real chorea, though often erroneously designated congenital chorea. A sudden noise, fear of falling, unexpected touch of the skin, a puff of air, or other cause of emotion, or of centripetal cerebro-spinal influence, will excite increase of contraction and of jerking of the affected limbs. Instead of instability, or mere want of co-ordination, we prefer the term choreic irritability, which describes better the condition of such patients.

preponderance over others (not necessarily a *spasm* of it, although in certain cases the distortion is due to spasm, as already said, when it occurs in children who have suffered from asphyxia neonatorum). When, therefore, in a given case, we see reason to reject the sole influence of weight of the body, as well as rickets, paralysis and spasm in producing the distortion, we are thrown back upon that contraction of previously healthy muscle which is apt to ensue when the points of insertion of muscles are loosened, and their leverages changed by a general weakness of the joint structures, such as we have stated to exist in ill-nourished children. The muscular contraction in question has been of long duration, and has adapted the muscles to its shortened length, when they may remain an obstacle to cure (structural shortening). Formerly, on account of this shortening, we resorted frequently in these cases to section of the biceps femoris, and any neighbouring tense fascial and ligamentous structures. The resistance to rectification of form is felt to proceed from the structures on the outer side of the articulation, the biceps tendon, and probably the subjacent external lateral ligament.

FIG. 38.

*Flexion, with knock-knees and severe equinus from spastic contraction. From Little, 'On Deformities.'*

It has been seen from the above (fig. 36) that a paralytic in-knee may be associated with curved leg bones. Whether this curvature springs from weakness of bone, owing to such impairment of nutrition and thinning of the bone as usually accompanies paralytic wasting and contraction of

muscles (see p. 48), or whether it be due to rachitism, can only be proved by minute anatomical demonstration (see p. 57). The balance of evidence is in favour of simple wasting and thinning and yielding of the bone under statical influence. The commencement of the curvature after the age of early childhood, say after the age of five or six years, when the paralysis has already existed several years, and the absence of rickety symptoms elsewhere, constitute, in our opinion, conclusive evidence against a rickety origin. Occasionally in genu-valgum, whatever its origin, we have known "strumous" knee set up after a fall. We have also seen "knee *disease*" set up as the consequence of injudicious violent methods of treatment employed for the rectification of genu-valgum. See section on treatment.

The illustrations of knee ankylosis (figs. 24, 25, 26) and strumous knee contraction show the varied and complicated states of disturbance of form and position, of which the contracted and more or less completely ankylosed knee joint is made up. Fig. 25 represents a knee affected with true or bony ankylosis in the position of slight flexion, considerable subluxation backwards and outwards of the head of the tibia, marked inward inclination of the knee, with a corresponding marked abduction of the tibia. The ankylosis is completed by ossification of the patella to the external condyle. The points of similarity of this specimen to ordinary in-knee, except as regards the sub-luxation and the ankylosis, are apparent. These anatomical preparations are confirmatory of the statement made (p. 2) that whenever the connecting structures, which in health firmly bind together and retain in their places the bony components of the knee joint, the femur, the tibia and the patella are weakened and relaxed by disease; whatever may be the nature of the disease, the joint assumes more or less completely the form of genu-valgum, unless the distortion be counteracted by art.

The fig. 26, p. 63, drawn from the living, illustrates the appearance during life of the anatomical arrangement shown in fig. 25, the difference in this case being that the long-standing ankylosis was incomplete, and therefore removable, probably because the articular disease was of strumous character. The inversion of the knee, the subluxation of the head of the tibia, the abduction of the shaft of this bone, and the situation of the patella upon the external part of the outer condyle, denoted by the black patch in the drawing, are the same.

At page 64 some observations were made on rheumatism in connection with in-knee, or, more properly speaking, in-knee induced by rheumatism. We have seen many patients, often elderly people, with chronic knee rheumatism of moderate degree of severity; others, with "rheumatic neuralgia," as they termed it, with exquisite suffering. Usually there was present in these cases some serous effusion (synovitis serosa) in the bursa beneath the ligamentum patellæ, or within the joint itself. Such patients were accustomed to be driven out, and hobbled about with the assistance of one or two sticks. It often has appeared that the pain and lameness complained of were out of proportion to the actual amount of rheumatic or other diseased action going on in the part. Usually, as in most knee affections, the pain has been referred to the inside and neighbouring part of the front of the internal condyle. It is worthy of remark that some of these long-suffering patients had been under the care of a succession of able men—who probably from being unaccustomed to the study of abnormal changes of form of parts, comprehended under the name of distortions—had apparently failed to observe the existence of some degree of inward inclination of knee, for they had omitted to take any therapeutic steps to correct the evil of it. Owing to the inversion the normal comparative perpendicularity was infringed, and the pain and inconvenience attending even awkward attempts

at locomotion were aggravated. See the section on treatment.

As a further anatomical illustration of the universality of the production of the prominent features of genu-valgum, when from any cause of disease the knee joint is weakened in its connections, we refer to the representation (p. 64) of a diseased knee, believed to have originated in rheumatism. It probably commenced with ordinary sub-acute serous effusion into the joint, and consequent loosening of knee connections, and gradually some abnormal flexion with genu-valgoid abduction and rotation outwards of the tibia took place. The pressure of the tibia against the external condyle led, after long-continued use of the limb during awkward modes of locomotion, to the utmost conceivable destructive internal joint changes, the reciprocal wearing away of the articulating facets of the tibia until the head of this bone approached the form of a pestle, and erosion and disappearance of the external condyle of the femur, through which a very unworthy species of new joint was formed. Doubtless muscular action, especially that of the biceps, had here been an important factor in increasing distortion, as it is in cases of ordinary knock-knee; but we believe it may be regarded as certain that the greater part of the mechanical changes, represented in this preparation, was due to statical influence,—the act of walking during an improper bearing of the parts upon one another owing to loosening of their several connections, precisely as we have shown distorted knee to arise in the infant and adolescent from atonic relaxation of fibrous tissues, or in the infant from rachitic softening of the bony structures.

With slight atonic or idiopathic knee inversion the child in walking is often observed to turn the toes in, though when the feet are examined it is found that each foot presents

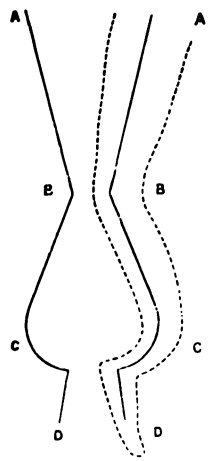
what the nurse calls a double-ankle, *i. e.*, there is a double prominence on the inside of the ankle, one below the other, the uppermost being the internal malleolus, the lower the depressed internal margin of the scaphoid. Nevertheless such feet are not flat (flat-foot, platt-fuss) and a well developed arch remains, and the ankle joint remains movable in all normal directions, even to excess, owing to co-existing want of tone in the ankle ligaments and muscles, a state of things in the ankle strictly analogous to atonic in-knee in its early stage. In these cases if the laxity does not subside at an early age, thorough flat-foot, *i. e.*, persistent loss of arch, even when the patient is seated, with limitation of ankle movement, and some *structural* adapted shortening of the muscles (tendons) on the outside of the ankle (peronei and extensor communis digitorum, and, in extreme cases, tibialis ant.), may set in. The nearer the approach of the feet to the condition of thorough flat-foot, the greater is the tendency of the patient to persistent eversion of the toes. Thorough flat-foot, in our opinion, more often accompanies rachitic than atonic cases. See p. 7.

Nature or gravity works in the lower extremities exactly as in the spinal column affected with scoliosis, or twisting of the spine, which, as we have already said, is a strictly analogous distortion to in-knee, occurring in distinct forms, —the atonic and the rachitic.* Precisely as we find in scoliosis one or more successive curves established by the action of gravity to compensate for the first curve, and thus enable the individual to preserve his balance and maintain himself in a better poised attitude, so we see in the successive deformities of the lower extremities the attempt of the individual by means of his volition, perhaps automatically exer-

* The reader who desires to further investigate this subject is recommended to consult Alexander Shaw's article on "Lateral Curvature of the Spine," in 'Holmes's System of Surgery,' 2nd edition; and that by us under the head of "Scoliosis," in the 3rd edition.

cised, to gradually effect by a succession of curves or zig-zags the approximation of the stand-points of the body—the feet, so as to bring them as near the median line as is required for security and convenience in walking. To how great an extent Nature fails in her efforts is shown by the progressive augmentation of deformity seen in the worst cases of genu-valgum (p. 45).

Diagram B.




*Schematic arrangement of curved limbs.* A A, *black lines intended to indicate the course of the femurs;* B B, *ditto, of the tibiæ;* C C, *ditto, re-entering curve of the lower third of the tibia towards the median line;* D D, *feet normally everted. The dotted lines around the left schematic lines represent the contour of the supposed deformed limb covered with flesh.*

It is in young subjects in whom the distortion is far from attaining the completeness of the deformity, shown at p. 45, that the successive workings of gravity can be watched. The right limb, fig. 4, p. 6, which is the less distorted, appears more under the control of the will, whilst the left extremity appears to have further escaped from its influence. The right knee is seen to be acting as a better buttress to its fellow, whilst the right foot appears to be struggling towards the median line, and is inverted, whilst its fellow is more passive, and is everted.

The annexed diagram is intended to represent the successive angles or curves formed in the course of a lower extremity through the action of gravity, and the efforts of the individual manifested by muscular action and mode of standing to regain the perpendicular. We see many young children, usually rickety, in whom, in addition to moderate double in-knee, we find the tibiæ fairly straight in their upper halves or two-thirds, the lowest portions, however, being deflected inwards towards

the perpendicular line. We have also seen young non-rachitic subjects of in-knee presenting similar curves to that represented in the diagram, so that, as already stated, mere curvature of bone, taken alone, is not a certain sign of rachitis. We have before mentioned the occurrence of curvature of bones, in addition to yielding inwards of knee, from atonic causes.

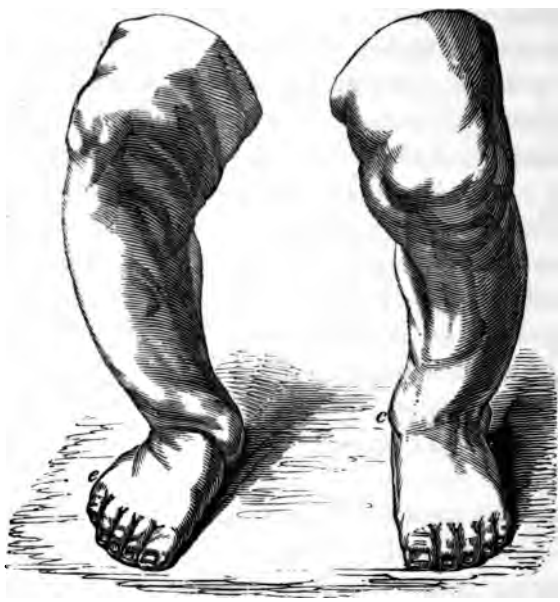
We have also spoken of curvature of bone from organic want of nutrition, and atrophy of bone in paralytic cases. Mr. Hutchinson, at the Pathological Society's Discussion, 1880, remarked that he had seen bone curvatures due to syphilis. Considering the frequent intervention of this disease in the medical history of childhood, the fact of syphilitic bone curvatures appeared to be a disturbing element in the pathology of bone curvature, and especially in relation to rachitic curvatures. It has been satisfactory to find that when a member of the recent International Medical Congress (see Trans., 1881) endeavoured to connect all rachitis with syphilis, not one speaker was found to endorse this opinion.

It may be remembered that the writers on rachitis, during the middle of the last century, described seven or eight forms of this disease, one of which was the syphilitic form, which has long been abolished by subsequent writers. In fact a better study of this disease has, as in so many other diseases, simplified the knowledge of it.

To return for a moment to the theory here introduced to account by mechanical agency for the particular curves manifested in bones weakened by rachitis, admitting at the same time the influence in production exercised by the more bulky mass of muscles, we direct attention to a common form of rachitic curvature (fig. 39). We may premise that we do not remember having seen a rachitic curved femur (not due to former fracture) in which rachitic curvature of leg bones did not co-exist. Now let the reader

observe the thigh curvature forwards and outwards, the leg curvature forwards and inwards, and the ankle twist, owing to which the point of the foot is directed outwardly, the weight being mainly borne by the heel and great toe. The student will better understand the production of out-knee

FIG. 39.

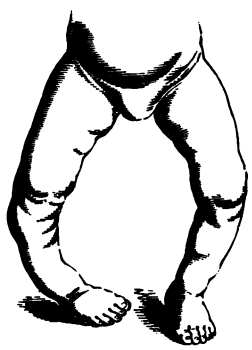


*A common form of rickety curvature of lower extremities: curved femur, out-knee, in-ankle, everted foot (talipes valgus), all more marked (in this instance) on the right side; (e) the outer margin of foot almost raised from the ground, the principal weight being borne through the great toe.* ***From Little,*** *'On Deformities.'*

(genu-varum) after comparing fig. 39 with fig. 18, and note the succession of curved zigzags which, in the interest of locomotion, gravity leads the limb to take. In figure 40 the right foot has an unusnal inward inclination, instead of an outward one, probably because the rickety child in question principally effected locomotion with this limb tucked beneath the nates, using the left limb as a paddle against the floor.

In illustration of the mode of production of curvature of thigh and leg bones we append (fig. 41, p. 104) the drawing of an adolescent, presenting the results of infantile hemiphlegia, —attenuation of the left side and extremities especial wasting of the left thigh and leg, comparative robustness of the right arm and right side of the trunk, greater stoutness and length of the right thigh, greater length of right leg, right foot flat. Right out-knee and outward curvature of right leg bones exist as the consequence of its disproportionate length, owing to accommodative, structural shortening, compensating in some degree for the diminished length of the opposite limb. The spinal curvatures in the drawing were temporary only, for they entirely disappeared when the left foot was raised from the ground by the interposition of a book of sufficient thickness to compensate for the shortening. The drawing further shows the completeness with which the successive spinal curvatures, in a manner and with a purpose analogous to that in which gravity operates in producing curvatures of bones and yielding of the joints in the lower extremities, enables the head to be carried in the erect position, and an upright position of the frame, as a whole, is maintained. But the greatest interest here afforded by this case is that the outward curvature of the right lower limb is simply accommodative, and not due to rachitic softening. There was no where to be found in the economy any indication of previous rachitis. It may be said, therefore, that curvature may occur in sound bones through shortening accommodative to short bones in the opposite limb, in the bones of paralytic limbs through their organic

Fig. 40.



*Rachitic out-knee curvatures of long bones in a young child. From Little, 'On Deformities.'*

nutrition being deficient, in the bones of persons affected with atony of fibrous and osseous structures without signs of rickets, and, above all and most commonly, in distinctly rachitic subjects.

Fig. 41.

*Accommodative curve of right lower extremity, and apparent, but temporary, spinal curvature only, due to infantile hemiphlegia. From Little, 'On Deformities.'*

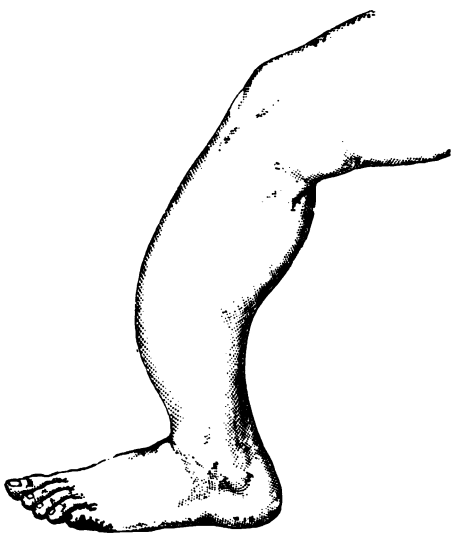
When we are considering the action of the superincumbent weight upon the limbs which are weakened by loss of tone of the fibrous or osseous structures, we should remember that just as either the femur or the tibia, when softened, is disposed to yield rather towards the middle of its length than in any other position,* (see fig. 42), so the part of the lower extremity which will be most disposed to yield to gravity will be that part which is nearest to the middle of its entire length, *viz.*, the knee; thus in-knee will be engendered under the other favouring circumstances which have already been considered—the knee being in fact nearly midway between the summit of the head of the femur and the sole of the foot.

As an aid to diagnosis of rickets, Sir W. Jenner (Report of Discuss. at Patholog. Soc., 1880) dwelt upon the well-known form of the skull, especially the depression over the suture between the two frontal eminences. This particular sign of rickets, which is a positive one, is like any other sign, not invariably present, or not always present in so marked a degree. Quite as

* 'Traité du rakitis,' par Levacher de la Feutrie, Paris, 1772, p. 84.

characteristic of rickets is the undue projection and acuteness of those eminences, for they are frequently out of proportion to the depth of the suture. As already stated we should depend upon more than a single sign. Delay in

FIG. 42.



*One of the commonest forms of rickety curvature, to illustrate the tendency to yielding towards the middle of the shaft.*

closure of the fontanelles is one of the signs of rickets, just as in another manner it becomes the sign of another diseased state, hydrocephalus, through the individual bones having been mechanically kept asunder by the effused intracranial fluid. From an early period a connected disease between rickets and hydrocephalus has been believed to exist,—hydro-rachitis. Further study of rachitis, hydrocephalus, and hydro-rachitis is required to determine whether this is a separate form of disease, or whether it merely represents a simultaneous combination of symptoms of the same disease.

The recent discussions at the Pathological Society and at the International Medical Congress on the diagnosis of rickets from other diseases, and the pains we have here taken to enumerate the clinical and other distinctions between them, would justify the idea that, after so long observation as that to which rachitis has been subjected during two centuries and a half, it is still difficult for the physician to discriminate it. We believe that in having eliminated from rickets the greater number of in-knee and in- or weak-ankle cases, just as Guérin and Alexander Shaw a generation ago showed that scoliosis is commonly not a rachitic affection, we shall have done good service in the way of diagnosis and treatment.

Amongst the well-marked symptoms of rickets may be mentioned the clefts or deep creases in the integuments in the less severe cases, as at the upper and inner part of the thigh, even in fat children, *which are signs of bent bones beneath.* In the later stages greater hairiness of the general surface is sometimes perceptible. It occurs mainly on the back, arms and sides of the face.* The late production of teeth, and their incomplete character as regards both enamel and dentine, with premature shedding, almost forms a pathognomonic sign. We may often in the later age of rickety subjects note in the succession of imperfect rings of enamel, and of discoloured dentine in the second set of teeth, the phases of temporary alternate amelioration and deterioration of the former constitutional state of the child.† The physiopathological relation between the symptom of unusual hairiness and that of defective teeth, if any, has not been determined. We venture the following remarks for further consideration as to the possible relation of undue hairiness to defective solidification of bones in rickets. It is known that the primary mould of the bone in the embryo is a

* Aitken: 'Science and Practice of Medicine,' 1866.

† See Hutchinson: Pathol. Transact., 1880.

tolerably firm one, composed of some form of the gelatinous group of animal substances, in which first cartilaginous cells, and later on bone particles, are developed, as if poured in for the purpose of successive degrees of hardening. We know also that by long soaking, in an acid solution, a healthy bone removed from the body, the mineral matters can be removed, and the bone be restored to a quasi-fœtal condition. The normally firm bone is thereby shown to consist essentially of a gelatinous element and a bone element, plus blood, blood vessels and nerve elements. If we regard the rachitic infant's condition as one of abnormal nutrition, whether hereditarily predisposed (p. 83) or acquired, and that tooth and bone belong to the same chemical category, may not the bone phenomena of rachitis, owing to abnormal nutrition, represent a quasi more or less complete starvation of the bones, and misappropriation of the primary essential building up materials, *viz.*, of the gelatine compound constituting the mould of the bone, and of the earthy more solidifying material? The exudation of the sanguineous jelly found to exist in the interior and on the surfaces of the most affected portions may excite absorption from the bones of the gelatine case and contained earthy materials. If this be so, may not the unemployed gelatine material appear in the shape of *keratin* in, and give rise to, the superabundant hair-growth, and the earthy matters appear as phosphatic deposits in the infant's urine?*

* Having stated (p. 31) that Jules Guérin had not distinguished non-rachitic in-knee from the rachitic form, and having corrected that error (p. 33) by showing that, in the very recently published 'Transactions of the International Congress of 1881,' this distinguished physician had described four forms, we owed it to him to examine his intermediate writings on distortions, and to note that in his 'Rapport sur les traitements orthopédiques,' 1848, p. 98, speaking of "déviation du genou en dedans," he mentions that out of five cases two were not rickety.

## ON TREATMENT.

THE experience acquired, and published by us a generation ago, showed the treatment of in-knee in infants, children, and adolescents to be one of the most successful offices in which the practitioner in deformities could be engaged. We can affirm that of this distortion amongst cases at all ages, in all classes of society, in private practice, and in hospitals general and special, we have only met with two cases which had been successfully rebellious to restoration,* as far as the actual knee inversion was concerned.

It will be noticed farther on how large a number of previously reputed irremediable cases of in-knee and rickety

* One of these, a non-rachitic case in the right knee of a young woman, which had been perfectly straightened, but which remained straight only so long as mechanical apparatus was used. When she stood unsupported the knee yielded inwards, the joint was loose and "wobbly." Although the limb could be straightened it was obvious that the hard and soft structures composing and surrounding the articulation had not adapted themselves to their restored proper relations (p. 29). In short, the recovery of tone by the soft structures and interstitial absorption of excess of bony tissue in one part, and interstitial deposit where wanted in another part, as had invariably been observed by us, had not taken place. We were informed that in this supposed case of inveterate in-knee that the patient, if not also the medical attendant, had "played fast and loose" with it. We only saw this case once in medical consultation. The second one, rachitic, aged thirteen, one leg presenting in-knee, the other out-knee, with considerable curvature of thigh and leg bones, had worn instruments for years. The parent and instrument maker stated that the distortion had much diminished under instrumental treatment. The instruments were continued two years longer; the knee joints were straightened, but were loose, and relapsed on removal of support. Osteotomy was proposed for the curvatures, but declined.

curvatures have, since the introduction of osteotomy, turned up from public cripples' homes, union-houses, and the remote abodes of the poorest classes in large cities. If the knowledge of the existence of the means of prevention of distortion during early childhood had permeated the profession at large,—if the example afforded by the establishment of orthopædic hospitals, and subsequently of special departments for orthopædic practice in the general hospitals in the metropolis, had been largely followed elsewhere,—such large arrears of humanity would not have been left to the present generation of surgeons to clear off.

Advantage to the completion of the knowledge of in-knee, as of other morbid conditions, and their treatment, arises when observers approach the subject from a different point of view, and at different periods of time. Of late years *severe* genu-valgum has presented itself to us less frequently than a generation ago, presumably because in this large centre, London, the diffusion of successful methods of treating the earlier stages, as in infancy and childhood, has reduced the number of severe knock-knees in adolescents and adults at the present day. Judging from the experience of Professor Macewen, of Glasgow, an unusually large number of uncured adolescent and adult cases was to be found in that neighbourhood until he brought his mind and hands to the relief of the mass of lameness, deformity, and suffering. It is impossible to avoid the conclusion that either poverty of the parents of so many sufferers, or ignorance that means of prevention and cure were available, or other unsuspected cause, can account for so many instances of this particular complaint being found by him.

The treatment of infantile cases, whatever their origin, consists of two parts,—the constitutional, that by which it is sought to ameliorate the general health, removing at the same time the affections of internal organs, which are apt to be associated with constitutional debility at this suscep-

tible period of life, and the mechanical means employed to support weak, and straighten distorted, joints.

All infantile cases of in-knee, whether rachitic or non-rachitic, may, as regards mechanical treatment, be classed together, and treated upon the same principles and by the same means, modified in particular cases according to the degree and variety of the distortion. When treating of the causes and nature of in-knee (p. 67), and speaking of the origin from neglect of dietetic and hygienic influences, we have foreshadowed our opinion of the constitutional remedies necessary to check the progress of distortion, and shall, therefore, leave this subject to the individual judgment and experience of every physician. We will permit ourselves one comprehensive remark only, that as soon as infantile debility, which is apt to precede deformity, shows itself, the child manifesting less firmness of flesh, weakness of loins, consequent inability to sit up, delayed appearance of teeth, or when actual knee weakness and morbid tendency to inversion of knee appears, the diet of the hand-fed fast-growing infant should be changed; water should be discarded for milk, or the nursing mother's probable insufficiency of supply and quality be exchanged for a more robust diet,—farinaceous and vegetable food should be introduced; meat in small quantities, suitably prepared, be allowed; a dry food, as it were, be substituted for a too watery one. In mere atonic laxity and distortion we have little faith in special chemical foods or in drugs to meet the child's requirements, except when other symptoms of disordered health are present. The same remark applies to the external use of imported or artificial sea *water*, and other external applications. Such expedients tend to divert attention from the more immediately necessary mechanical means to avert or remedy incipient distortion.

The constitutional treatment of the rachitic infant, also, should be considered on the same principles as the case

arising simply from unsuitable diet. If the mother be of rachitic family, a wet-nurse of a sounder constitution should be preferred for the child. This is not the place to enter on the full consideration of the nature and treatment of the extensive disease of the system at large understood by rachitis. We have remarked (p. 83) that in our opinion this disease is as special a disease as cancer or tubercle, and other diseases which are believed to arise from special sources. It appears, for the most part, in our opinion, hereditary, if not always so. If it does not destroy life by urgent rachitic complications, hydrocephalus, bronchitis, convulsions, disorders of the chylopoietic viscera, it follows as regards its manifestations in the osseous structures two distinct stages, those of softening and of subsequent undue hardening of them; and as regards the teeth two stages of growth, the first in which there is little or no ordinary dentine or enamel deposited, and a later stage, as in the second set, in which increase of bone tissue and enamel takes place.

One thing appears to be as certain of rachitis as of the special diseases mentioned, that medicine can neither arrest nor prolong the time which, as regards the bones and teeth, is occupied in the above-mentioned stages. We continually see children affected with rachitic distortions who have traversed the disorder of rickets untended by physicians, and to whom no remedies have been applied, who have reached the stage of eburnation and cessation of the rachitis in the system at the same age as those who had been subjected to medical treatment. Except as to the distortions and intercurrent rachitic internal complications, it may be said that the disease runs its course and subsides at a fixed period inherent to it.*

* Wunderlich, C. A.: 'Handbuch der Pathologie und Therapie,' vol. ii., p. 939. Jenner: 'Med. Times and Gazette,' vol. i., 1860. Holmes: 'System of Surgery,' vol. iv., p. 843. Athol. A. Johnson: ditto, vol. iii., p. 750.

Moreover, as stated (p. 78), rachitis never occurs after infantile age, and never recurs during puberty, adolescent or adult age in those who were seized with it in infancy. Elsewhere we have shown that those writers on this distortion, who have asserted that rickets originates during adolescence or adult age, have so stated because of their propossessions that this distortion only occurs in rachitic subjects. Notwithstanding the views here expressed as to the nature and course of rachitis, and the dependence of one form of knee inversion upon it, we do not advise relinquishment of the use of alkaline earths when, in rachitis, the condition of the gastric secretion denotes undue acidity, or of steel wine—cod liver oil, sometimes with small doses of orange wine, when mal-assimilation indicates inpending marasmus.

Until statistics shall have enabled others to confirm the views here announced it would be wrong to throw away a possible chance of benefit to rachitic subjects, and not to employ articles of at least a neutral, if not a sustaining, quality. We have had children brought to us who have taken, with the decidedly mischievous effect of burdening the alimentary canal, cretaceous, phosphatic and alkaline compounds, and advertised chemical foods, continuously for three years, owing to the belief that such things are really nutritious, just as we have had a patient suffering from a neurosis bring with her a prescription containing strychnine, which she had taken continuously for twelve years.*

When treating rachitic cases, in which we have reason to believe that either of the parents is of rachitic descent, and that the child is old enough to be, or must be, hand-fed, we should remember, before prescribing drugs, that milk, oat-meal, wheat-flour, mutton and beef contain a large

* See Bouvier on the incorrectly asserted sovereign virtues of ol. morrhuæ in rickets, and on what he calls the "dephosphiation of the blood," *op. cit.*

quantity of earthy phosphates in an easily assimilable form to supply the place of any possible hereditary deficiency of such ingredients in the blood.

The surgical treatment may be divided into two parts: that which consists in manipulations by a competent attendant, or in the suitable application of splints and other mechanical contrivances for the purpose of bringing the knee structures by gentle means into a proper relation to each other, and effacing the in-knee temporarily and permanently (see p. 51); and that which consists of more abrupt means, such as have been used in severe cases,—tenotomy, forcibly straightening under anæsthesia, and osteotomy.

In every mode of treatment the surgeon has to bear in mind that the principle involved in successful treatment is to place and retain the knee in such a position that the articular surfaces of the external side of the joint be relieved from undue pressure, in order that they, when thus relieved, may gradually return to the normal state of growth, shape, and size, a tendency to which, under favourable circumstances, is always apparent in the economy.

C. Hueter proposes to effect this object by bending the knee to a right angle, and fixing it in that position by means of bandages, thus effectually preventing the patient from using the limb. He speaks contentedly of this method. He omits to state how long he was obliged to continue it. It is obvious that it is not applicable when both limbs are affected, unless the patient is to be confined to the couch or perambulator. If applicable to a single limb, and the patient be allowed to move about, with the help of a crutch or stick, it is objectionable, because of the tendency which then would arise to undue use of the other limb, which probably will already have some tendency to the same disease. The plan is novel and interesting by its showing a distinct recognition of the correct principle of treatment, the relief

of certain knee structures from undue pressure, and the encouragement of them to renewed growth. We have resorted to the plaster of Paris, starch, or gum-bandage. This plan is applicable in very slight cases, where the surgeon contemplates employing it for only two or three weeks. All familiar with the treatment of distortions are aware of the evil of retaining any joint many days at a time in an extended position, compressed throughout in a close-fitting circular direction, especially during infancy, when growth is very rapid. We have seen a knee *permanently* lessened in size compared with its fellow after tight bandaging. It is true that the previously deficient external portions of the femur and tibia may be released from pressure, and thus be encouraged to grow; but during a long-continued fixed extended position of the knee joint, the normal shape of the articular eminences is likely to be more or less changed, owing to the prolonged entire repose in one position; and we know that partial ankylosis is thus easily produced. Another great objection is that a return to movement of the joint, after the plaster of Paris treatment, is a painful proceeding.

The first step to be taken in the treatment of infantile cases is to teach the parent, "rubber" or nurse the proper manner in which the part can be manipulated with prompt unmistakable benefit. It has been stated (p. 27) that in the young an abnormal lateral mobility of the knee (wobbling) is a marked symptom of in-knee. If the recumbent child's legs appear to be abducted, each to about 50° or 60°, each knee can successively be brought by the attendant from the position, *a*, *b*, nearly to *a*—*d* (see diagram A, p. 27), by the most gentle painless pressure. The degree of temporary restoration thus effected, is the measure of the degree of improper movement of the knee. It is not necessary that the parent or rubber should at the first attempt entirely overcome the inward bulge of the knee;

after every day's attempts this will become easier. It has been mentioned (p. 56) that if the knee be bent the genu-valgum disappears; for the same reason during manipulations it is necessary that the manipulator should keep the limb extended, but not hyper-extended. The nurse or rubber should not be too hasty or forward with her measures; she should be gentle, capable of simultaneously amusing the child or withdrawing its attention from her doings. If the child should resist, which may follow too tight grasping of the limb, or be impatient and withdraw the limb, he bends the knee or rotates the thigh, so as to defeat the rubber's intention to straighten it: tact on the part of the nurse or rubber soon overcomes any difficulty.

In figs. 43 and 44 are represented the manner in which we have taught parents and rubbers to economise time and

FIG. 43.

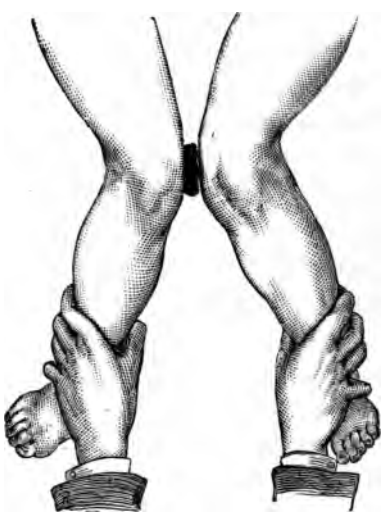
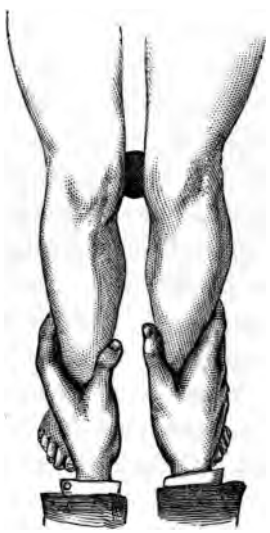


FIG. 44.



trouble by straightening the two limbs at the same time. In both figures a disc of cork, $\frac{1}{2}$ or $\frac{3}{4}$ inch thick, according to the age of the patient, is represented, which is covered with

a layer of cotton-wool and sewn up in silk. The disc serves as a fulcrum between both internal condyles, whilst each leg being grasped by one hand of the rubber serves as a lever. By the rubber gradually bringing her two hands gently together both in-knees are temporarily converted into straight knees, and by repetition of the process after a few days, in the young child, each limb *could be* carried beyond the straight line, even to the opposite condition of genu-extrorsum. The "knack" of doing this valuable movement of temporary restoration is soon acquired. It should be pursued with gentleness, as we have said, the nurse watchfully noting the temper and disposition of the child, so as to pause when the child appears disquieted. The process may be repeated several times daily, each "sitting" being at three or four hours interval. If the child is old enough to follow directions, say over three years, it may be instructed to stand erect against a wall, with the padded disc between the condyles, and the inner margins of the feet touching, the limbs temporarily verging to genu-extrorsum. Many slight degrees of in-knee, brought for consultation in the earliest stage by parents on account of the child being accustomed to turn the toes in, or because the child has "double-ankles," "flat-foot," or spurious talipes-valgus, are entirely cured by the parents who have been taught this mode of manipulation, without the employment of splints, moderate exercise of limbs being permitted.

A most simple mechanical aid, from which we have derived benefit in the earliest stage of atonic, strumous, or rheumatic in-knee, consists in placing a soft cushion $\frac{1}{8}$ inch thick, large enough to cover the whole of the inside of the internal condyle, or condyles, and teaching the parent or nurse to secure it, in its proper position, by a roller bandage. The standing exercise, mentioned above, should be practised as there described.

When the in-knee is somewhat more advanced, support from one or two splints during a considerable portion of each twenty-four hours may be needed. It should be emphatically borne in mind that in treatment by instrumental appliances it is necessary to prevent voluntary bending of the knee during their use. The value of this advice admits of no question. Like Hueter's plan it effects one important object, that of freeing the external side of the joint from pressure.

The simplest, least expensive and least burdensome of appliances are light ordinary wooden splints, properly padded, secured in position by ordinary soft, somewhat yielding, roller bandages. The first of these splints, six to eight inches long, padded along its whole length, for a child under two years, requires to be lightly secured behind the knee to prevent bending by means of a roller bandage. If the distortion be so considerable that it cannot be sufficiently diminished by such gentle pressure of the surgeon's hand as will enable him to apply satisfactorily an ordinary straight splint, as above described, he will find advantage in the substitution of a light metal padded splint, jointed in the horizontal direction, represented in fig. 45. Such a splint, lightly secured by a roller bandage, will remain evenly applied to the back of the knee, however great may be the degree of genu-valgum. Afterwards a second splint, reaching from below the trochanter to the outer ankle, padded only for a distance of two to three inches at the two extremities, should be bandaged along the outside of the limb. See fig. 46. This second splint when properly applied, so that the outer hollow side of the knee is brought almost into contact with it, at once removes the in-knee distortion. Under these favouring circumstances, if the child be under

Fig. 45.

the age of two years, suitable manipulations and mechanical appliances will effect entire recovery within from two to four months. If between two and four years old the time required may extend from three to six months, the child not needing afterwards any retentive apparatus. The bandages should be lightly sewn in all directions to prevent ingenious and curious little fingers undoing and loosening them. They never require to be tightly applied. They should be removed night and morning for the purposes of cleanliness and ablution, for the practice of the manipulations, described p. 114, and for a *single bending* of the joint night and morning, whilst the nurse sedulously supports with one hand the internal parts of the joint. They should be reapplied with as little delay as possible. The parent or nurse, after being once or twice shown the manner of applying the splints, should have no difficulty with them. If circumstances permit, the services of a trained rubber and manipulator of distortions may be obtained for this part of the treatment; the child being allowed to spend nearly all its time on the floor. It should not be allowed to stand unsupported by splints until the deformity is seen to have disappeared, even after the splints have been removed from the limbs for some hours.

Fig. 46.

If treatment has been neglected it will be found that in children between the ages of five and ten years the elastic nature of the resistance to replacement, above mentioned, has gradually given place to a more rigid condition of the structures on the outside of the knee joint. Irons should in this case be substituted for the wooden splints. It is indispensable to prompt success that these should at first permit no movement at the knee joint. In the use of irons, as of splints, the surgeon should remember that the gentle con-

tinuous force employed in knock-knee should operate simultaneously in two directions, *viz.*, from before, backwards, in order to prevent bending of the knee; and from within, outwards, to prevent inward yielding of it. To fulfil these objects the "irons" should be furnished for each knee with a double firm buck-skin knee strap, so attached and secured that one part shall prevent flexion, the other shall prevent inward yielding. The gradual straightening of the knee should be accomplished by the gradual tightening of this double strap. During the first few days and nights the instruments should be uninterruptedly worn. They should be so made as to permit a soft; light, loose, proper shoe to be substituted at night for the day-walking boot, without removal of the knee part of the apparatus. In these cases no confinement to the house is required, walking in moderation may be permitted. At the present day such irons, either single or double to each leg, are obtainable at most instrument makers. The annexed instrument (diagram c) may be relied upon for the straightening of even the worst adolescent cases. The patients soon become accustomed to the inconvenient method of ascending stairs and sitting with stiff knees, and end by acquiring a dexterity in performing

DIAGRAM C.

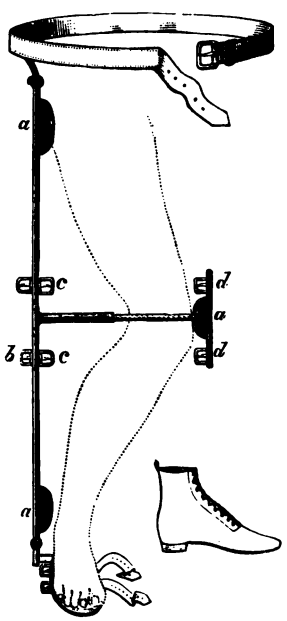



DIAGRAM C.—*Schematic representation of walking and night instrument for rectification of severe adolescent knock-knee. It consists of an upright stem, with free movement joints at hip and ankle, attached below to an ordinary foot-piece, and transferable to an ordinary day boot, to which it may be secured by a spring below the heel: (a a) on the upright stem are pads on the fulcra to*

*protect the skin over the trochanter and the external malleolus from pressure; (a) on the inside of the knee is to indicate a pad to protect this part from pressure. Leading from this pad to the upright stem is a metal back-piece, consisting of two parts, the left-hand half being the female screw, and the right half a male screw. By turning round the piece of metal (d a d), to which the male screw is attached, this is made to enter the female screw, so that gradually the pad (a) opposite the inside of the knee is approximated to the upright stem, and the inverted knee joint gradually directed towards the perpendicular. If the knee be more inverted than the above dotted outline represents, the treatment should be commenced with the use of a proportionately longer male screw. In the case of both limbs being so severely affected, it will be more convenient to treat the patient recumbent, by means of an apparatus on the principle of the diagram* D, *until he attains a sufficiently improved state to sit up or move about. To avoid encumbering the drawing several adjuvant essential contrivances have been omitted. These are a padded metal band and a thigh strap, which should be attached to the upright stem, opposite the middle of the thigh, to draw the thigh towards the perpendicular; a similar band and strap should be opposite the middle of the leg. Besides these a stout buck-skin strap should pass from the upright at (b b) successively over the front, the inside, and around the back of the knee, and be buckled on the upright at (b b), so as to draw the knee outwards; and another buck-skin strap pass from the buckles (c c) to the buckles at (d d), so as to keep the knee completely extended. If all these contrivances are gradually brought during the first few days to a state of sufficient tension and pressure, the patient will experience no pain, excoriation, or undue pressure; the knee even in stout adolescents will be completely straightened. It is desirable that once a day the knee in the still-growing individual be bent, so as to avoid stiffening of the joint in the extended position. It is well to order the apparatus to have a ring-catch knee movement. If the knee of the worst class, whether or no section of biceps femoris has been done, be, as it should be, straightened within eight or ten weeks, the patient may be allowed, by means of the ring-catch, to walk with free movement of the joint a part of, or after a time the whole of, the day.*

what at first were difficult and inconvenient feats of activity.

We venture here to insist that the surgeon should no more entrust a surgical instrument maker, "bone-setter," or nurse, to direct the patient or the friends in what manner, at what time or rate, gentle force is to be applied to a distorted knee, than he would entrust such persons to set a broken bone, or to restore to the proper form a badly united

one; as much knowledge of anatomy and pathology as is possessed by the qualified medical practitioner is as necessary in one case as in the other. Some of our surgical brethren who have justified resort to unnecessary ablation of tarsal bones in congenital varus in young children, or, the performance of osteotomy in juvenile cases of knock-knee, on the ground of "ordinary orthopædic treatment," having failed, have confounded the previous handing over of cases to the mechanic ignorant of anatomy and pathology with the treatment which should have been carried out by the orthopædic surgeon, if they themselves felt unable or ashamed to accomplish it. The shades of Leonardo da Vinci, Camper, Scarpa, and Stromeyer—who have all given their attention to distortions, and the mechanical means of relieving them—might rise up against this disregard of the saying of the noble Roman: "Homo sum, nihil humani a me alienum puto."

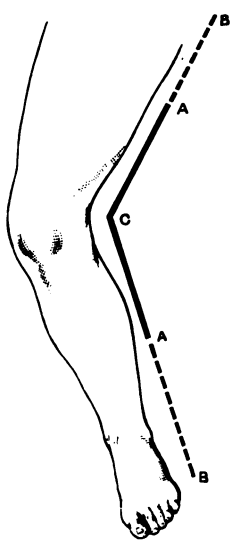
Irons often have failed, because owing to their mode of construction they have acted as helps to locomotion, rather than as curative agents. We see other splints constructed for cure of severe in-knee exhibiting just pretensions of superior fitness, having regard to the necessity of drawing the knee outwards, but without any effective contrivance for maintaining a completely extended state of the joint whilst the morbid inversion is being counteracted, or for preventing the rotation forwards and outwards of the whole member, and, as is especially noticed by C. Hueter (*op. cit.*), of the internal condyle.

Many years ago we introduced into use here a metal splint, adapted to the outer side of the in-knee, furnished with a rack and pinion, or endless screw, for gradually drawing the knee outwards, similar to that which has been figured by Volkmann (*op. cit.*). We found, however, that by its not being attached to the foot and hip it became displaced, through the internal condyle and the limb generally

working round in an outward direction. Moreover, this apparatus does not advantageously permit locomotion, for the weight of the trunk destroys the regulating machinery, necessitates repairs, causes arrest of progress, consequent relapse, and loss of progress already made.

It is remarkable how little regard to the simplest mechanical principles is frequently shown by instrument makers, and apparently acquiesced in by surgeons. Not unfrequently we see a side splint for in-knee of the relative length, shown by the dark line A to A (diagram D), furnished with a proper adjusting screw at the angle of the inclined knee, C, and secured to the knee by suitable straps. Whatever beneficial influence can be effected by so short a splint as that indicated by the dark line, and the benefit, as the result has shown, has been very small, because of the shortness of the leverage, and the absence of any means of completely preventing bending of the joint, becomes many times augmented by increasing the leverage, as from B to B. The efficacy of the apparatus is still further increased by extending it to the hip above and to the foot below.

Diagram D.




It is not to be wondered at that Linhart, for example (*op. cit.*, p. 92), should write:—"I will not state that orthopædic instruments are useless, but I do maintain that when anything is gained it has only been after years' use of them, and only when *through the most careful application of them* a change of nutrition in the bones can be obtained, *i. e.*, in youth; in all other cases the surgeon must content himself with a slight amendment, or the prevention of

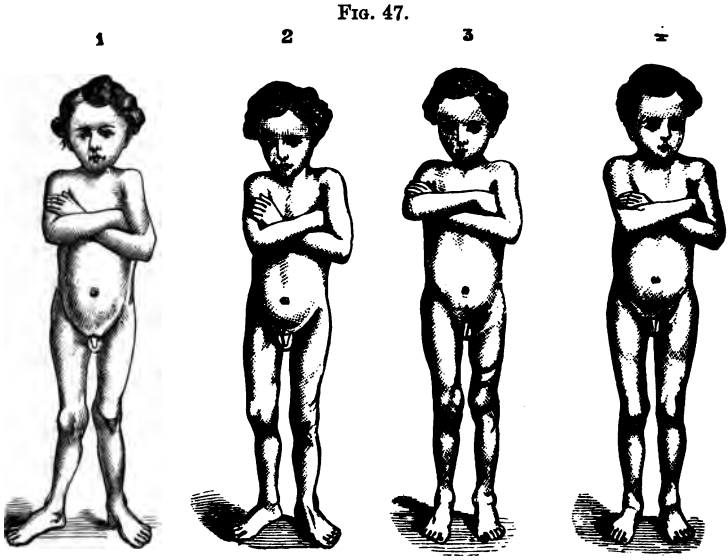
further mischief" (the italics are ours). "In no case, except one, a boy eight or nine years old, have I seen a cure effected." Or that Mikulicz (*op. cit.*, p. 707) should assert, from his experience, that in treating considerable deformity mechanically with a side splint the time required to effect a cure is from 120 days to 7 years. Unfortunately he did not discover that the omission of a back splint to prevent bending of the knee, and excluding the hip and foot from the apparatus, were fatal to his attempts at cure of severe cases. Mikulicz actually fixed the hip joint by a plaster of Paris bandage. Most surgeons have, by this time, discovered the inconveniences of plaster of Paris as compared with other available materials.

In the severest adolescent cases, where the feet are separated twenty inches and upwards, the treatment may be commenced by a metallic or wooden ordinary fracture box, regulated by a lateral ratchet screw, and the apparatus, diagram c, p. 119, be substituted when the limb has, in the course of two, three, or four weeks, been brought into so improved a position that the walking apparatus can be fitted without violence to the limb.

It might reasonably be apprehended by some surgeons that by permitting necessary walking to a patient with in-knee, not straighter than the dotted outline (diagram c), the weight of the trunk would mischievously interfere with the treatment. We regard some exercise (in the open air, if possible) as a necessary part of the treatment in adolescents; and especial experience has abundantly shown us that, although the weight of the trunk borne on the limb is an obstacle, the cases steadily mend if the apparatus be constructed and employed upon the principles we have laid down. It cannot be too often repeated that when we have to treat a severe distortion it is not necessary to resort to tight bandaging, tight buckling of straps and apparatus, *i. e.*, severe treatment. We find it desirable to maintain

the slightest possible strain upon the resisting limb, to have the curb tangible but comparatively loose, not to attempt too rapid an advance, less complaint of pain, chafing, or pressure-wounds should necessitate relaxation or suspension of treatment. We laid down the rule of *arte non vi* a generation ago in the mechanical part of the treatment of all distortions. It is as useful, nay as necessary, in the treatment of in-knee, as in the training of an unruly animal, a vicious temper, or an insane patient.

FIG. 47.




*August 10.* *September 4.* *September 30.* *November 14.*

*Medium degree of atonic in-knee of five years standing, from a series of photographs transferred by photography to the wood blocks. No previous treatment had been employed, as it had been expected that the patient would outgrow "the weakness."*

The above four figures (fig. 47) will well illustrate the rapidity with which freedom from distortion may be effected by attention to the rules here laid down. The patient, aged eight, son of a Hindoo physician, brought up partly by hand,

was in consequence of weakness unable to run alone until one year and half old. The gait had continued unsteady, with proneness to frequent falls. The father had discovered no other signs of rickets than the distortion and debility; the general health had been in other respects good. He was of good average height and intelligence.

Fig. 47, No. 1, represents his appearance on August 10th, when the treatment by instruments was commenced. The only peculiar observation to be made regarding the knees, which cannot be made out from the drawing, is that they have lost the lateral "play" they are said to have formerly possessed, being, on the contrary, so accustomed to the inverted position that they cannot be straightened at once with the hands without giving pain. We could discover no trace of past rachitis, unless some abdominal fulness were attributable to that disorder. We were assured by the attendants of the child that his abdomen was not larger than that of the average child of vegetarian rice-eaters of the same age. The instruments consisted of a light plain iron on the outside of each limb, furnished with free joints at hip and ankle, a "ring-catch" movement at the knee and a "*stop*" to obviate hyper-extension, a double knee-cap as described at diagram c (p. 119), but with a simple, not expanding, back-piece. The attendants were shown the kind of manipulations required to be effected. It was enjoined that upon no account the child should be permitted to stand for a single moment, unless supported by the apparatus. It was arranged that a photograph of the actual progress made should be sent to us once a fortnight. As the case was only of medium severity he was permitted to sleep without the irons. The dates appended to each of the figures show a progressive improvement, and that at the end of nine weeks, November 14th, he could stand unsupported, no distortion remaining. During the following two months the ring-catch at the knee was released during one-half of

each day, so that complete extension of the knees was then only maintained for half of each day. During the fifth and six months he wore the instruments with constant free motion at every joint, and then laid them aside altogether without relapse.

It is worthy of remark that the grandmother, in whose charge the child remained in the country, remarked, as parents in other cases have done when the instruments have been rightly designed and well adjusted, that he had never had a moment's uneasiness from them; on the contrary had, whilst wearing them, recovered the natural buoyancy of his age and greater strength than he had possessed before having recourse to them.

It is also worthy of remark that children who have with difficulty effected locomotion from in-knee are observed to improve in appetite and strength directly they feel the relief afforded by the support of the apparatus. In fact, with the help of support they are enabled to take much more healthy exercise, and the economy is spared the outlay which was occasioned by previous difficult, fatiguing, or painful efforts. We have given the above single illustration. The same might have been done with adolescent cases. It is, however, less easy to obtain photographic records of cases of adolescents of either sex.

In proportion as the health of children affected with this distortion from debility improves, and especially in the cases which have arisen from unmistakable rickets, in which undue hardening of bones succeeds to delayed ossification or softening, the whole of the fibrous structure acquires an increase of firmness and rigidity, so that between the ages of seven and fourteen, or thereabouts, the question of the necessity for division of the resisting outer hamstring and lateral ligament of the joint occurs. Previously to 1850 we frequently performed this operation with satisfaction, as to the aid afforded by it to restoration. The distinct gain from it

was very evident immediately after the operation, and for two or three weeks afterwards; but on comparing the actual time expended upon cases treated by mechanical means only, and those treated with the additional help of division of tendon and ligament, the gain of time was only measured by two or three weeks immediately following the surgical operation. This did not compensate either the operator or the parent. It is a matter of experience in the treatment of this distortion, as of most physical (as well as moral) evils, that it is easier to make a marked impression upon, and removal of, a considerable part of the evil when it is first attacked than during the after stages of the treatment, and the last trace of the complaint offers the strongest resistance. It is the omission to remove this last trace of distortion in knock-knee and other deformities, whatever the mode of treatment selected may be, and the consequent premature cessation of treatment, which cause so many relapses, and which have encouraged the adoption of other more radical measures.

The partial eburnation or hardening of the bones, preceded by softening of them, commonly takes place at four or before the age of five years. It is therefore necessary, in the treatment of rachitic *curvatures* of bones, to effect straightening at an early age; any straightening of them afterwards will be very slow, and will depend as much upon the spontaneous restoration due to the play of the muscles during use of the affected parts as upon therapeutic circumstances. It may be well to state here that a small amount of rachitic bone curvature may prevent the part from rivalling the beauty of the Venus de Medici, yet provided the limb as a general whole, represents a fairly straight column and fairly natural contour from above downwards, it need not be the subject of treatment after the age of five.

As regards this matter the female has an advantage over the male sex. In the female the naturally greater rotundity in the form of the limbs at puberty, due to greater

deposit of subcutaneous adipose tissue, serves to conceal small amounts of permanent curvature.

The introduction of the use of anæsthetics since 1850, and the resort to straightening under their influence, has been of service, and, in our opinion, enables the surgeon to limit still further the use of section of outer hamstring and the lateral ligament. Although we have coupled the biceps femoris and external lateral ligament together, experience leads to the conclusion that section of the ligament is less defensible than that of the tendon. The ligament, when elongated by mechanical extension, does not so readily recontract as the muscle, which, being an active contractile organ, may return to the struggle, but finally gives way when, by persistent aid of the apparatus, the antagonists on the opposite side of the limb assert their balancing influence. Even up to the age of sixteen or seventeen, or so long as active growth is going on, especially those cases which first present themselves during adolescence and over-rapid growth, in which the feet, being from twelve to twenty inches apart, are placed in a straight, jointless iron, worn along the outside of the knee night and day, are remedied solely by mechanical means. No interference with health or cessation of the occupation in which the patient was engaged before the treatment need occur. An aid to the determination of the treatment most desirable in the individual case is afforded by the manual application of pressure without or with the aid of an anæsthetic. If the resistance is felt to be an elastic one when the joint resistance is tested without anæsthesia, or if, with the help of anæsthesia, the knee is felt to yield with moderate manual force, the case may with confidence be left to steady continuous unvacillating mechanical treatment. It is different with severe rachitic cases, in which the growth is prematurely arrested, in which curvature of bones constitutes the greatest obstacle to restoration, and

in which, without the use of mischievous violence, little improvement in position is effected by manual efforts.

Very violent straightening of in-knee under anæsthesia has been largely employed, but is open to the same objections which apply to violent methods in deformities in general. Those in use in the present day are due to want of experience and want of patience. The violent method of reducing distortions was sufficiently tested many years ago by Sartorius, Dieffenbach, Louvrier,* and us. Many modern surgeons have employed it in knee contraction and knee inversion; it has often resulted in fractured bones, separation of epiphyses, laceration of ligaments, rupture of popliteal blood-vessels, and popliteal nerve, and not the least of the evils produced by it has been inflammation succeeded by "strumous" disease. Violence thus used is measureless and misplaced. When effected by the united force of the surgeon and his assistant—often of several assistants—it degenerates into jerking violence, and cannot be arrested at a precise moment; it is misplaced because it cannot always be confined to the most contracted and most resisting structures.

Sometimes we have operated a *deux temps*, and have severed the biceps tendon and the external lateral ligament, and allowed the small punctures to unite before resorting to violent straightening by the hand. This is preferable to the use of violence instantly after section of the above structures. No proof has been afforded that with the aid of these proceedings any gain has resulted to the patient, as regards pain, time, and inconvenience, equal to that afforded by the gradual use of instruments.

The experience of Billroth † as to "rédressement forcé,"

* See Siebold's 'Sammlung seltener und auserlesener Chir. Beobachtungen,' Band iii., p. 258. Stromeyer: 'Beiträge zur operativen orthopädik,' p. 25. Dieffenbach: 'Ueber die Durchschneidung der Muskeln und Sehnen,' 1841. Little: 'Treatise on Club-foot and Analogous Distortions,' Introduction, p. xlix., 1839.

† Billroth: "Clinical Surgery," 'Trans. of New Syd. Soc.,' 1881.

and as to section of the biceps tendon and the external lateral ligament, coincides with that published by us a generation ago.

After complete straightening of severe cases, a superabundance of tissues on the internal side of the knee may exist. The skin and subjacent structures appear loose, and favour the tendency to relapse. This disproportion does not long continue in children, as from the growth of the limbs the natural relation becomes established. But in adolescents and adults, who have respectively nearly or wholly completed their growth, its removal is more slow and uncertain; hence a long continuance of weakness.*

When such rapid forcible measures are employed much is apparently gained at the moment, but apparatus is much less easily borne after such treatment than without its use, and in the long run the tortoise is apt to outrun the hare.

* On this subject we wrote as follows in 'Treatise on Deformities,' pp. 221, 222:—"For some years past the author has wholly discontinued the use of operation in genu-valgum, having ascertained by comparison of the time occupied in treatment with and without operation, that, although with the operation a rapid improvement is at first visible, the ultimate result is the same, whether or no the operation be performed. In no other than adults did the operation ever appear justifiable. The length of time requisite for adjustment of articular surfaces of the femur and tibia in severe adult cases renders the gain in the first instance by operation of little moment. The author has found the inversion yield in the severest cases within three months to improved mechanical treatment, consisting either of wooden splints, hinged at outside of knee, and straightened by a ratchet or male and female screw, or with a strong common stiff iron attached to a shoe, properly adapted, and duly removed for friction and manipulations. At present the author does not even find it necessary to confine such severe cases to the recumbent position during the daytime. He has treated, with the aid of irons, many adolescents who have followed sedentary occupations during the whole period they were under observation. *Habitual* voluntary flexion of the knee should not in these cases be permitted until many months after the inversion has been overcome."

If force be absolutely necessary the author prefers the most modern form of applying force — supra-condylar osteotomy; for when after this operation the limb is secured in a straight position, a gap is formed on the external margin of the femur at the place of division, and the external condyle is lowered to a corresponding amount. By the consequent change of relation of the leg the tibia is adducted, and the genu-valgum disappears. The gap in the femur artificially made is substituted as it were for the analogous gap felt in the straightened genu-valgum in the young by the surgeon's hand, when the laxity of the joint permits the manœuvre. After Macewen's operation Nature fills up the triangular gap in the femur by callus, just as Nature by a return to natural growth where wanted, in the femur and tibia, fills up the gap between the external condyle and the opposing articulating surface, when the surgeon, with the aid of mechanical apparatus without osteotomy, has succeeded in holding those structures asunder, so as to enable her to act. See figs. 21 and 49.

Dr. Shaffer* remarks:—"If students were taught how to recognise the earliest stage of progressive deformities of all types the necessity for surgical operation would be further removed; and I have made it my rule, and it is a good one, never to use the knife to remove deformity when I can avoid it. We have no right to say, I can accomplish the *removal of the deformity* quicker by its use. Will the ultimate usefulness of the member, or members, be greater if I remove the deformity quickly, and merely save time thereby? *We have no right as conscientious surgeons to think of our time or effort* in orthopædic practice."

We have occasionally seen in consultation a former in-knee, or an out-knee, which has been straightened by instrumental means, but which has remained loose, the

* Newton M. Shaffer: 'On Knock-knee and Bow-legs,' New York, 1881.

joint structures of which have not adapted themselves to their new relations, and sometimes this condition is accompanied with curvature of leg bones. In these cases, if the curvature has been considerable we have advised osteotomy, and have succeeded in giving stability to the knee by enclosing it in leather or felt-paraffin splints and bandages, worn night and day, which were removed for an occasional bending of the joint. As soon as practicable we have allowed free motion in light irons, until the knees have recovered firmness and their due bearings.

We have spoken of the comparative ease with which even severe distortions yield to continuous mechanical treatment, during which the member is not *tightly* or painfully secured. At first a difficulty in explaining the success achieved was experienced. We considered that continuous gentle action of the instrument acted solely after the manner of dropping water upon stone; but we were gradually enabled to perceive that the patient's muscles on the uncontracted side of the member assist replacement.

A proof of the aid given to recovery by the muscles on the uncontracted side of the limb is afforded by the following fact, sometimes spontaneously mentioned by a patient as respects the knee, when it is being brought by instrumental treatment from the bent partially ankylosed state to a straight position. A few days after the limb has been placed in a "ratchet" or "rack and pinion" extension apparatus, and progress to the amount of, say, 10 to 15 degrees has been made, the patient may feel what he describes as a tremulous movement in the patella and its ligament attached to the tibia, which is due primarily to the previously stretched elongated condition of the quadriceps femoris, and its connected patella and ligament having been relaxed and loosened, now that the joint has been somewhat straightened. The quadriceps femoris, after months or years of previous disuse, consequent upon the knee disease

and contraction, feels itself, now that it is loosened, out of gear, as it were, and only after a series of tremulous weak efforts adapts itself to its reduced range. In like manner, in in-knee, the sartorius and gracilis may help restoration when the opportunity is offered them.

We shall rejoice if any words of ours shall lead to the employment of gentle means. Violence, proved to be unnecessary, is to be regarded as a wrong ignorantly inflicted, inasmuch as other well-approved, long-practised, successful gentle means are available for restoration.*

A long continued experience has shown that, to *cure* in-knee, besides diet and hygiene, two things are necessary, *viz.*, to keep the knee extended during the treatment by an unyielding apparatus, to employ a similar contrivance to maintain adduction of the leg. Also by recognising the necessity of relieving the external condyle and the opposing part of the tibia from pressure, in-knee has even been arrested by its being maintained in a bent position, as when a boy has been apprenticed to a tailor, in the work of which the patient should sit *à la Turque*, or as by Hueter's plan, described p. 113. In the elastic stage of in-knee, riding astride, without stirrups, on a narrow-backed donkey, Shetland pony, or rocking-horse is a valuable aid to cure. Riding, where available, may in many severe cases, be resorted to, at daily intervals, removal of instruments being then permissible. In such cases the patient should not be allowed to stand or walk unsupported by apparatus, until it is ascertained that it can be done without the knees again giving way.

Infants even, who cannot walk, evince no pain or inconvenience from the treatment, it being permitted them to spend their day upon the floor; in them the apparatus

* Dr. Buckminster Brown, of Boston, U.S., has published illustrations of cases successfully treated by instruments: 'Orthopædic Surgery,' 1863.

may also be removed for a couple of hours night and morning. We would remind the surgeon of an axiom of John Bell, applicable to our present subject, to the effect that "force is only successful where it is not needed." If the utmost gentleness be used Nature will do her work with the utmost docility. All bandages and straps require to be applied with a comparative looseness that may seem ridiculous to the inexperienced. Children of two or three years and upwards, able to walk, may wear the apparatus day and night, and walk about as much as they like in the daytime with reasonable rest, the apparatus being removed morning and evening for a *few minutes* only for cleanliness and to enable the nurse twice daily, as directed, to bend the knee-joint once.

Mechanical treatment which can be carried out by the mother and nurse when properly instructed and watched by the surgeon is the proper remedy for all cases of in-knee in early childhood, whether rachitic or not. The greater number of young adolescent cases of genu-valgum, when taken in time, are also quickly recoverable without the use of violence and without osteotomy.

In all cases the patient may follow his nursery, school, or business vocation. As soon as it is found that the knees evince no decided tendency to return to the valgus form directly the controlling apparatus is removed, a gradually extended permission to habitually use the parts in full mobility may be given.

It is rarely necessary in any but the severely neglected or unrelieved cases, even in the adolescent up to the age of sixteen or seventeen, to confine the patient to the couch or bed. If an in-knee, which is not one of the slightest degree, be temporarily obliterated by the use of splints or irons without the knee having previously been extended in the true direction, *i.e.*, the patella presenting forwards when the patient stands up, the straightening, *i.e.*, the removal of the dis-

tortion, is only apparent. It will be found that a rotation of the limb on its axis, at the hip, has taken place, owing to which the popliteal region presents more or less inwards instead of backwards, and the patella presents outwards. We discovered, many years ago, the necessity of basing the instrumental rectification upon preliminary fixation of the knee in the extended position, and have been interested by finding that Amesbury, before us, plainly recognised this necessary preliminary. Ignorance of it explains the fact that many able surgeons who have written on orthopædic subjects have entirely failed in their instrumental treatment.

It is lamentable that surgeons have not investigated and discovered the cause of their own failure, and *carefully applied* instruments themselves or superintended as well as directed their application, and in fact given as much care to the "setting" of a distorted as of a broken limb. The surgeon has, in fact, too often handed the case to the instrument-maker; if the surgeon had personally treated it, he—being then responsible as to instruments—might have discovered the cause of his want of success.

A certain superciliousness on the part of many surgeons towards any mode of treatment not carried out under their own eyes in their own particular hospital has been a feature (we will hope) of the departing generation of surgeons.

Volkmann (*op. cit.*), a surgeon of European reputation, has thought it necessary to apologise when detailing the shape and qualities of the orthopædic instruments he has employed and depicted. Surgeons omit any similar apology when describing the particular catheter or lithotrite employed. We fail to see, in a matter of humanity and professional occupation in the relief of suffering, why apology was not as much needed in the instance of one set of instruments as of the other. The apology was a relict of the day when the physician only condescended so far as to direct the barber, surgeon, or bone-setter what he should do,

forgetting the ancient saying of Pliny already quoted. It reminds us of a much later day when we heard an able operating surgeon say that "he left the prescribing of drugs to the physician."

It is found even in advanced adolescent cases, that if the mechanical treatment be continuous day and night for three or four weeks, or in most severe cases until the limb is straight, no advance of screw or strap being permitted by the surgeon until the previous advance has been thoroughly well borne, considerable exercise with stiff knees may often be allowed during the second month of mechanical treatment. The effect of this liberal exercise in the straight position is to bring about such a change in the articular surfaces of the femur and tibia as will fit them for future correct locomotion without irons. The change in question consists in renewed growth of the cartilage and bone on the outer half of the articulating surface, and probably absorption and reduction in length of the internal corresponding parts of the joint.

Whatever change the ligaments have undergone (p. 38) is at the same time rectified, undue length of ligaments on one side of the joint, and unfolding (see p. 41) and lengthening of ligaments on the outer side taking place.

Fig. 48 represents the thigh and leg bones of a child or young adolescent, from Mikulicz, affected with in-knee, and especially the relations of the femur and tibia, and of their respective epiphyses. It exhibits increased abnormal growth of the internal diaphysial part of the femur, and of the adjacent part of the epiphysis. The increase of these parts is more apparent than real, because Mikulicz has made no allowance for smallness of the external condyle, which is due to arrested development or absorption, consequent on compression.

At fig. 49 we have placed the same bones in their proper relation for a sound limb, by which is shown the

gap which would exist between the external condyle and the opposite articular surface of the tibia but for the dotted outlines which we have added to the outer parts

FIG. 48.

FIG. 49.

*The femur in* fig. 49 *has been represented as too upright.*

of the articular surfaces, in order to show the natural growth of these parts, which ensues when the limb is restored by proper mechanical treatment.

At the third month of the treatment in severe adult cases the patient when seated may, by means of the "ring-catch," remain with his knees flexed or extended at will. When he regains the erect posture, or is walking, the surgeon should allow half of the exercise to be effected with free motion of the joint, and half in the fixed extended position. With these precautions the muscles are gradually educated to correct relations, action, and strength, and the passive structures (ligaments and bones)

are tended and assisted to resume their natural bearings and functions.

Even at the end of the third month the curiosity and desire of the parent and adolescent patient to ascertain whether locomotion can be spontaneously and properly effected without the aid of apparatus should not be indulged. Whilst the orthopædic surgeon is assisting Nature to effect a cure by restoring the normal relation of parts in form, position, and strength, so that the influence of gravity can be properly withstood, he can no more tolerate "playing fast and loose" during mechanical treatment of in-knee than he can when conducting the mechanical treatment of a broken bone.

The vulgar mind considers that the "doctor" has exhibited a mysterious skill, when the surgeon or the bone-setter has placed broken bones in their natural relation, and endeavours to maintain them in a right position by mechanical or instrumental treatment, and readily comprehends the necessity of some weeks' persevering retention of them in the natural situation. In like manner they are easily led to understand the reasons for the necessity of the precautions to be followed in the management of serious distortions, if the surgeon understands the work in hand, takes the trouble to firmly explain his operations to the patient and friends, and the certainty of success if they do not "play fast and loose" with the apparatus and the limb.

We have said and written much on the necessity of gentleness and perseverance on the part of the surgeon and his subordinates. We may add that technical tact and mental tact and confidence are necessary on his part.

We can affirm that the worst cases of in-knee may be effectually restored by the above means, and when the case mainly depends upon knee deviation. The case is different when the shafts of the long bones are much bent and eburnation of them is far advanced.

We have for many years practised without seeing an abrasion, bruise, or superficial slough, or even disturbance of sleep at night, during the treatment of this complaint, after the first or second night's use of suitable apparatus.

We have shown (p. 116) that many cases before the age of seven or eight are so rapidly straightened, and the parts so rapidly re-adapted for correct use and restored, that in a few weeks, or in two or three months, they may be permitted to stand alone, and take some exercise unsupported by apparatus. In advanced adolescence and adult age the patient needs to wear his "supports," whilst freely using his limbs, from six months to one or two years. We have never known the most severe case wear them beyond two years, although we have been consulted in cases where mechanical treatment, injudicious in its character and application, had been ineffectually used for several years. See p. 30.

When permission to stand and walk unsupported has been granted, the case needs to be watched, lest inversion should return owing to over-exercise, or through omission of the manipulations, rubbings, and special movements and postures, which have been recommended for the early stages. We have never seen it return.

This distortion, except in the very rare congenital instances, is always preventible. It is one of the advantages of having become acquainted with the etiology and morbid anatomy of each variety of this physical change of form, and of the manner in which Nature, when assisted by art, effects a cure, that the medical practitioner, when confronted by infantile weakness and relaxation during rapid growth, by retarded independent locomotion, by rickets, by knee injury from accident, disease, or rheumatism, and other causes mentioned in these pages, knows that amongst other probabilities he may anticipate the occurrence of more or less morbid knee inversion and aggravation of his patient's condition, and can by judicious measures prevent

its occurrence, or obviate its increase when the slightest manifestation of it is present. The arrest of the earliest stage may be accomplished by manipulations and other gentle means, which we have enumerated (p. 109 *et seq.*). Few maladies, in short, are so easily preventible through the co-operation of the surgeon and parent as this distortion. This is especially true of such deformities as we have caused to be pictured in the earlier pages of this work. This being the case we might venture to predict that after the lapse of a few years, owing to our teaching and that of contemporaries, such specimens of in-knee distortion will only be found in anatomical museums or libraries, and that violent methods of treatment, and sundry surgical operations now employed, will be immediately recognised as inapplicable.

Nearly thirty years ago (Little, 'On Deformities,' p. 267), speaking of severe congenital varus, we expressed the opinion that a generation later, the representations of inveterate congenital club-foot given in that work, might have only a historical value. We might have written the same of adult severe in-knee. We were then too sanguine. It is the misfortune of humanity, and of our profession, that although much improvement has been accomplished, the sanguine hopes of 1853 have not been realised. May we on the present occasion be more successful in stimulating society and the profession to render impossible amongst the needy classes these forms of severe distortion, which it has been the lot of the present generation to witness!

Having asserted the practicability of remedying the most severe cases of adolescents and adults by mechanical means only, there remains to be considered the advisability of depending upon those means, now that by the combined influence of Esmarch's mode of rendering operations bloodless, of Lister's antiseptic treatment of wounds, and of the proofs afforded by Macewen's large personal experience of osteotomy operations, the almost absolute safety with which

section of the thigh and leg bones can be effected has been shown.

We published the particulars* of the first osteotomy operation for a deformity, performed in this country by Mr. L. Stromeyer Little, at the National Orthopædie Hospital in 1865, and ventured to predict that in a few years osteotomy would become a standard operation of surgery. This first operation, on an adult female in both lower limbs, performed with the saw by open wounds, was successful as to the removal of distortion, and recovery of power of walking erect. In the first leg some suppuration and constitutional disturbance occurred. The second limb was operated on after recovery from the first. As the result of acquired experience very slight suppuration or disturbance of health took place in the second. The exchange of the saw for the chisel in an operation for knee ankylosis, in 1868, by Mr. Little,† has led the way in this country to the substitution of the latter wherever practicable, and we see the fruits of the substitution of it, aided by the method of bloodless and antiseptic surgery, in the success which has attended Macewen, exhibiting a mortality after his operations of less than half per cent.

We had a voice in the above operations, but do not base the opinions we possess on the necessity for osteotomy upon the number of cases we have personally carried out, for, with the exception of having once ineffectually tried to pass a chain-saw around the neck of a thigh bone, we depend entirely upon observation of cases concerning which we have been consulted by other surgeons, and the published results of osteotomy treatment.

All surgeons do not speak of osteotomy for in-knee with equal *couleur de rose*. Mikulicz (*op. cit.*, p. 758) acknow-

* Holmes: 'System of Surgery,' 2nd edition; article, "Orthopædic Surgery."

† L. S. Little: 'Med. Chir. Trans.,' vol. 54, 1871.

ledges relapses after it, whether or no actual rachitic softening or disease elsewhere existed, and speaks of the necessity of precautionary irons to be worn for some months afterwards. It is certain that no justification for osteotomy can be found in cases in which the softened stage of rickety bones actually exists. In the second half of Mikulicz's list of cases of osteotomy for in-knee, the treatment occupied from seven to ten weeks.

We have already admitted the necessity for osteotomy with considerable bone curvature during adolescence when they have become eburnated, and when from the extent of the curvature the weight of the trunk to be borne by the limbs tends to augment the curvature of even the eburnated bones, and to cause displacement of the knee (genu-valgum) and of the ankle (flat-foot).

We know not to what extent the opinion, that it is desirable in young children to avoid, *if possible*, any considerable surgical operation, is in unison with that of the majority of operating surgeons. It is well known that *infants* are almost unconscious of an operation being done, and the use of anæsthetics in older children has entirely removed the pain of an operation from amongst the objections to it. But there are many children who, with high order of intelligence, combine a morbid sensibility to mental impressions, which re-acts badly upon the system at large, and which, added to the disadvantage of entire confinement for several weeks, favours the development of neurosis and disorders of nutrition, which it is most desirable to avoid. We write in this spirit of caution as to osteotomy operations, for the same reason as we have written against unnecessary tenotomy.

We may take as a type of less successful osteotomy of the tibia the comparatively recent experience of Billroth,* who lost two patients out of thirteen by "sepsis and

* *Op. cit.*

pyemia." If all the surgeons who have practised osteotomy in this country published their unsuccessful cases, as well as their successful ones, it would be easier to determine the exact risk which would be incurred by exchanging the slower mechanical treatment of severe genu-valgum in adolescents and adults for the more rapid proceeding of osteotomy.

The success which has been attained by Macewen ought surely to accompany subsequent surgeons. At the same time we would remark that the knowledge that living orthopædic physicians and surgeons have restored hundreds of adolescent and some adult in-knees without operation or violence;* and that Mikulicz† mentions "that in severe rachitis the bones offer less resistance during osteotomy to the chisel and mallet" than healthy bones,—a fact indirectly testified to by Macewen, who mentions that after having divided with the chisel the larger portion of the femur the remaining portion yields, after the manner of a green-stick fracture of a rickety bone, by the application of the surgeon's hands to it with the view of straightening the limb,—raises the presumption that many of the cases which have been cured by the aid of osteotomy would have recovered without it.

We have shown in these pages that the larger proportion of in-knee cases are in their early stages unconnected with curvature of bones, and are not, in our opinion, of rickety origin, and that in-knee is essentially a distortion *of the joint.* In deciding on the advantage of recourse to osteotomy, we should separate the question of in-knee from that of curvature of the leg bones. The reader has seen (p. 46) that Mayer, who first performed osteotomy for in-knee, severed the tibia, and removed a wedge-shaped portion of that bone. His example was largely followed. He appears

* See Guérin, also Little: 'Trans. of the International Med. Congress,' vol. iv., London, 1881.

† *Op. cit.*, p. 628.

to have overlooked the fact that in-knee, in the majority of cases, results from disturbance of relation of parts of the joint itself. He evidently looked upon knock-knee as a crooked limb, and straightened it much as a joiner might straighten a crooked piece of furniture, by cutting out a piece of it. A glance at Mayer's drawing (fig. 16, p. 46, in this work) will show, when compared with our diagram (p. 27, and figs. 48 and 49), how completely surgical attention to the joint will straighten the knee, and permit Nature to restore the balance in size between the external and internal condyles.

The mixing up of the fact of frequent co-existence of curvature of the leg bones, with the fact of in-knee *joint* distortion, combined with the knowledge that undue hardness of the curved leg bones is after a certain age irremovable by instrumental treatment, has given an undue impulse to recourse to osteotomy for in-knee, instead of causing the osteotomy to be restricted to the cure of the curvature. It is worthy of mention that when we assisted at a double osteotomy operation for considerable curvatures of the legs, in which slight genu-valgum co-existed, we observed that it was not until the fibula was severed that the knee-distortion disappeared.

As Macewen has stated (*op. cit.*), it is impossible to lay down a hard-and-fast line as to the cases in which osteotomy should be performed. We regard supra-condylar osteotomy, as compared with "brisement forcé," as the least violent method, and less liable to be followed by mischievous consequences to the knee joint.

We consider that in childhood osteotomy for uncomplicated in-knee is never necessary or justifiable. During adolescencc there are many cases of great inversion and distortion, in which the articular structures are still sufficiently yielding to permit comparatively prompt restoration by instrumental means. When in adolescents, however,

the peculiar curve in the femur, described by Linhart, Mikulicz, and Macewen, is very obvious, when the case has been long neglected, when the elasticity of the structures is lost, and the impairment of size of the external condyle and opposite articulating surface of the tibia is considerable; when the patella, moreover, has abandoned its natural groove between the condyles,—Macewen's operation may be regarded as indispensable.

Even in young boys we have found difficulty in maintaining the patella in position when it has been temporarily replaced. We have found the disposition to displacement subside after long-continued instrumentation. This displacement is a strong proof of great deficiency of the external condyle, a deficiency which may be felt by one hand of the surgeon, whilst he holds the patella in its proper place with the other hand. Remembering the concern such cases have afforded us we should regard this state of the patella as a powerful contributory reason for osteotomy when difficulty is experienced in keeping it in position, so long as the patient is permitted to take exercise.

Osteotomy becomes, then, the complement to mechanical treatment; and it will strike the reader who has followed the author's description of the physical obstacle to cure afforded by the deterioration of the outer half of the articulating knee surfaces, that correct instrumental treatment and supra-condylar osteotomy work towards cure in the same groove as regards "indication" of treatment.

In the rachitic cases termed genu-valgum, but in which considerable curvature of thigh and leg bones has more to do with the distortion than any changes in the knee joint, after the age of eight or ten years, when instrumental treatment can effect little improvement in the *curvatures*, osteotomy can alone be relied on. It should, however, be remembered that a moderate amount of permanent

curvature of thigh and leg bones is not incompatible with effective use in after life.

The treatment of out-knee curvature of legs and thighs, fig. 6 (genu-varum), requires to be conducted on the same principles as in-knee, but they should be reversed in the mode of application. Such "bow-legs," when severe, are less easy to manage than severe in-knee.

It cannot be too strongly inculcated upon the young surgeon that the object of treatment for the removal of many deformities should be less for the improvement of form than for the restoration of perfect function.

# ON THE OPERATION OF OSTEOTOMY.

Osteotomy, for the cure of distortions, has traversed a path similar to that of tenotomy, in having at first been performed by large open incisions, the structures in the vicinity of the divided bone being much disturbed by the movements of the saw, the operation being usually followed by severe constitutional disturbance, suppuration, and often by death. The pioneer in this operation was A. Mayer, who, in 1852, published a valuable paper on the subject. He appears to have first performed osteotomy ten years before the appearance of this publication.* So long ago as 1836 the author witnessed removal of a "hammer-toe" by Dieffenbach, in Berlin, with one touch of a chisel and mallet, without preliminary incision of the integuments. Langenbeck (1854), Pancoast (1859) and Grosse (1861) in America, L. Stromeyer Little (1865), Billroth† in Germany, and W. Adams (1869) in this country, have been the foremost, in point of time, in the employment of osteotomy for the treatment of ankylosis and distortions of bones.

It is of historical and therapeutic interest that in A. Mayer's first case—despite the making of a flap of skin over the head of the tibia half the width of the leg, and sawing with a Heine saw, and removal of a wedge of bone, the wound having being washed out with cold water to

* A. Mayer: 'Illustrirte Medicinische Zeitung,' July, 1852.

† Ueber die Verwendung vom Bildhauermeissel bei Osteotomieen, 'Wiener Med. Wochenschrift,' 1870.

remove "the sawdust"—the wound healed in six days, and the union of the bone was firm after twenty-four days. After recovery from the operation on the first limb, he operated the second limb. It was a disastrous operation, through his having divided the posterior tibial artery, nerve and veins. After many "accidents" the patient died from tetanus on the sixty-second day. In his fourth case, through breaking the chain of the saw, he found himself obliged to have recourse to two chisels from his *dissecting case!* These, doubtless, were not previously cleansed with carbolic acid solution, but by inserting them as deeply as possible in the groove already made in the bone he succeeded by main force in sundering the "very firmly resisting bone." Despite six months' of suppuration, bed-sores, &c., the patient wholly recovered.

These first efforts of Mayer were not encouraging to others engaged in the treatment of distortions, especially to those who had constantly succeeded in rectifying even the severest in-knee by instrumental means.

The surgeons who first followed in the steps of Mayer in regard to osteotomy, especially the American surgeons, followed rather the example set them by Rhea Barton in 1826, whom we have cited, and mostly directed their attention to hip ankylosis.

In 1875 Annandale severed the internal condyle of the femur for genu-valgum, with the disadvantages of opening the joint and severing all the ligaments; but he found few imitators. Ogston's operation was an improvement upon Annandale's.*

In later times Billroth adopted the more subcutaneous method of osteotomy by chisel and mallet, and in 1872 applied it to in-knee and out-knee, following the example of Lister in improved attention to wound dressing. In

* See a valuable lecture on this subject, by Mr. Barker, in the Brit. Med. Journal,' July, 1879.

1878 Billroth first performed supra-condylar osteotomy on the femur for in-knee.

We claim, however, for Mr. L. Stromeyer Little the merit of having first applied (in 1868) Stromeyer's principle of subcutaneous tenotomy to division of bone, as nearly as it is possible to apply it. The case was one of osseous union of the knee joint; the separation of the adherent bones was effected by a ¼ inch wide chisel and a mallet, the aperture in the integuments had only the size of the narrow chisel used, the wound was covered with a piece of lint only, and the limb bandaged, as in the case of a tenotomy wound. Cicatrisation occurred in six days without suppuration or other difficulty. Listerism may be said to have revolutionised the treatment of *open* wounds, but it has done nothing for subcutaneous tenotomy, as the minute punctures of this operation have invariably healed in thousands of cases within forty-eight or seventy-two hours, without trace of suppuration. As there is only a quasi-punctured wound in chisel osteotomy, there is no reason for Listerism.

We have seen that Macewen in supra-condylar osteotomy, and W. Adams in his division of the neck of the femur with the saw, find it sufficient merely to place a piece of carbolised or plain lint over the "subcutaneous" puncture-like wound. In cases where considerable detritus of bone has been left behind by the saw it becomes absorbed, as we have seen in several cases.

Many surgeons, who were insufficiently acquainted with the writings of their predecessors on the pathology and morbid anatomy of in-knee, having observed the undue prominence of the internal condyle, regarded this symptom as the pathognomonic one, and followed one another in their attack upon this part. They were not deterred by any apprehension as to opening the knee joint, and more than one surgeon freely exposed it. It is not known what

percentage of loss of limb or of life has attended this method of treatment.

In regard to it Mikulicz (*op. cit.*, p. 764) considers it an error to regard the internal condyle as the essence of the complaint, and shows that by detaching the internal condyle, and its removal upwards, an incongruence is established between the articular surfaces of the femur and tibia, and, as a consequence of it, an impairment of the subsequent mobility of the joint. He avers that after sawing off the condyle much force was required to straighten the limb.

In this laudable march of modern surgery in search of a successful mode of treating the cases believed to be inveterate, we are of opinion that old-fashioned ideas of the supposed influence of primitive malformation of bones have had as much mischievous influence in regard to the inversion of the knee joint (genu-valgum) as they have had in relation to supposed inveterate congenital club-foot.

Having assumed the accuracy of statements of many old observers of distortions, who in their ignorance of the links in the chain of causation of distortions met with in the embryo, the fœtus, and the infant, and *seen* to originate in childhood, and even after adult age,* surgeons have too readily employed the knife, the saw, and the gouge to remove or reduce that bony matter which appeared beyond the reach of milder measures; errors here, as elsewhere, having begotten further error. Osteotomy, for the relief of bent bones and of ankylosis, has rested upon surer indications.

We have endeavoured in that which we have written in the previous pages to bring before the reader all the facts known to us in the symptomatology, pathology, and morbid anatomy of in-knee, furnished by others or observed by ourselves, the result of such research being to show that

* See paper on etiology of club-foot, in 'Trans. of Internat. Med. Cong.' Lond., 1881.

in treating knee joint inversion we have to concentrate our attention more upon the external condyle, as compared with the internal one, and primarily to endeavour to better the condition of the external condyle, or of the external side of the joint, rather than of the internal side.

We are addressing a younger generation whose duty, as regards this distortion, is the cure of it in its earliest stage, and that of preventing it from attaining the inveterate stage, which can alone ever justly become the subject of operation of any kind.

Macewen (*op. cit.*) regards the numerous cases which he has operated as being due to curvature of the femur at its lower portion (see p. 41); but he also shows that he has in many cases been compelled to divide the leg bones on account of curvature of them. Many of his cases, therefore, were rachitic curvatures of the thigh and leg bones, and not cases of in-knee, *i. e.*, abnormal knee joint inclination inwards, through change of relation and form of the parts proper to the articulation. Those in which he did not find it necessary to divide the leg bones, as well as the femur, were probably non-rachitic.

Having reviewed a large number of cases operated by different surgeons, we have noticed the fact that in several instances, when both limbs were considered to require osteotomy, the operation on the second limb was postponed until recovery had taken place from the first operation. In several instances of death the fatality occurred after the second operation. We think it probable that, barring unavoidable accidents, the patient who has been confined to the house or hospital several weeks is, as regards his physical condition, a less favourable subject than he was at the time of operation of the first limb. This is still more likely to be the case, despite the encouragement afforded by the success of the first operation, as regards the *morale*.

A five or six weeks' confinement within doors, passed in

bed or without exercise, an average good diet being used, notwithstanding the best watchfulness of the surgeon, is not a good preparation for an osteotomy of thigh or leg, even when most skilfully performed under subcutaneous and antiseptic conditions, and reduced, as Macewen considers the surgical breach of continuity to be, from the rank of a compound fracture to that of a simple one.

It cannot be doubted that in a constitution in which any latent tendency to disturbance or disease of any of the internal organs, or system of organs, exists, a few weeks' confinement and deprivation of exercise after an operation, even if no great constitutional disturbance has been caused by the operation, may favour the outbreak of symptoms which may jeopardise its success, and even the patient's life. We have twice known a patient confined for five or six weeks, through so simple a matter as a fractured patella, die suddenly from heart disease, of which the existence had not been surmised by the friends or the medical attendant.

We consider, therefore, that Macewen was right in theory when he first undertook the performance of double and multiple subcutaneous osteotomy at the same time, and his experience has fully justified the proceeding.

It is unnecessary to review here the several methods of severing the thigh bone for severe in-knee, or the leg bones when curvature of these complicates the knee distortion, or has become the main deformity, which has been carried out by Annandale, Ogston, Barwell, Reeves, and others, for, in our opinion, the method pursued by Macewen is destined to supplant them all by its simplicity, celerity of performance, safety, and, moreover, by the perfection of its results. We have not only carefully perused all that this surgeon has written on the subject, but have had the opportunity, afforded by him, of witnessing his performance of a double operation, at a private clinical *séance* at Glasgow, and of thoroughly examining several adolescent patients,

and an adult, who had been operated on some months, and in one case two years previously. Even in the adult, who had been one of the most seriously affected, practised eyes and hands failed to discover more than the faintest sign that in-knee had ever existed.

In judging of the amount of spontaneous restoration and cure of in-knee through renewal of growth of the external condyle and opposite part of the tibia, as well as through arrest of undue growth of the internal condyle and its corresponding articular surface of the tibia, we refer the reader not only to the diagram A, figs. 20, 21, 49 and 51, but also to the observations respecting the normal proportions of these parts contained on page 22 *et seq.* From these it will be apparent that the degree of obliquity of the articular surfaces engendered by even so slight an excess in length of the internal over the external condyle, as may be compensated by three bronze pennies (fig. 9 *d*, page 23) placed beneath the latter, would suffice to allow of a not unimportant in-knee distortion. A very slight deficiency in one part and excess in the other will suffice to account for the amount of in-knee shown in figs. 11 and 12. Such cases readily yield, as we have sufficiently said, to mechanical treatment.

It is only in cases of very considerable disparity in the length of the two condyles, as at figs. 14, 30, and 50, that a large amount of letting down of the external condyle by supra-condylar osteotomy would be required. In this case the gap to be filled up by callus might be as great as that represented at fig. 51.

Dr. Macewen objects to the use of the word chisel, which he says conveys an erroneous idea of his instrument, which he prefers to call an osteotome. It is of tempered steel, handle and blade being one piece, and, strictly speaking, has no bevel, the straight line of either side of the blade being continued right up to the cutting edge, and a long and

taper wedge is thus formed. He advocates antiseptic precautions, and the use of the bloodless method of Esmarch and of Listerism. The operation is thus performed:—The limb is laid on its outer side on a pillow of damp sand, and a longitudinal incision of sufficient width is made with a scalpel, "at a point where the two following lines meet,—one drawn transversely a finger breadth above the superior tip of the external condyle, and a longitudinal one drawn half an inch in front of the adductor magnus tendon." The osteotome is to be passed down to the bone by the side of the scalpel, which is then withdrawn, and the former is turned into a transverse position, and made to penetrate the bone by successive blows with a mallet, being directed slightly forwards in order to avoid the femoral artery. Care must be taken to avoid impaction of the osteotome; and if the bone be very thick two or three instruments may be used, each more slender than its predecessor. The compact layer on the outer aspect of the limb need not be divided, as it yields easily on applying straightening force to the leg. The limb is then placed in a suitable splint, and the dressings, if all goes well, are not removed for a fortnight. Union is usually firm after six weeks, when the splints are removed, and the patient shortly afterwards is allowed to walk with crutches. Dr. Macewen states that, as a rule, ten weeks elapse from the operation till the time when the patient can walk about freely, and without artificial support.

We have here described the leading points in Macewen's proceeding. Simple as they are, we strongly advise every surgeon, about to operate by this method for the first time, to study all the minor points insisted upon by him;* for here, as elsewhere the great Wellington said, victory when traceable to the leader has depended upon attention to the smallest details.

Great as has been Macewen's success we venture to

* Macewen: 'Osteotomy,' London, 1880.

differ with him in the explanation of the nature of the subsequent physical changes effected in the femur and in the knee joint by his mode of operation.

Annexed is a representation (fig. 50) of a thigh bone from a genu-valgum case, from Macewen's work. We may remark that we have never met with so pronounced a prolongation of the internal condyle with so little apparent deterioration of the external one. The annexed figure represents the left femur. After having driven the thin, but wedge-like chisel two-thirds or three-fourths of the distance through the lower end of the shaft of the bone, he removes it, having unavoidably made a gap on the inside of the bone of at least the thickness of the substance of the chisel. He then completes the division of the bone by fracturing the undivided portion whilst in the act of forcibly adducting the limb with his hands. The gap formed by the chisel on the inside, caused by its increasing thickness as it is driven towards the external side, driving upwards and downwards the resisting bone substance, is of service, as far as it goes, in diminishing the length of the internal condylar part of the bone, and, *pro tanto*, favouring some degree of elevation of the internal condyle. We are of opinion, however, that when the external part of the femur is fractured in the act of forcibly straightening the limb (and we have observed that very slight force is needed for the purpose, owing to the length of leverage which the foot and leg afford) a considerable gap on the external side is formed, as represented by us at fig. 51. This therapeutic gap in the femur,

FIG. 50.

*Front view of the condylar end of left femur before osteotomy, from Macewen, p. 135; but placed by us in the direction the thigh bone would assume in tolerably severe in-knee. Probably a rickety case.*

destined to be filled up by callus, represents a substitute for the gap in the infant's leg shown by us in diagram A, p. 27, and which is formed whenever the surgeon, by the manœuvre there described, straightens the infant's early stage of in-knee. The therapeutic gap above the external condyle, resulting, we believe, from Macewen's method of operating, lets down the external condyle to its proper level, and when filled up by the callus supplies the deficiency in its length, found to exist by many observers as a consequence of previous absorption through undue compression and attrition. The filling up of this gap by callus has the advantage of preventing any loss of length of the limb through the osteotomy.

FIG. 51.

*The femur represented immediately after osteotomy, by Macewen's method, according to our experience, which differs in this respect from that of Dr. Macewen.*

We consider that if Macewen's figure (28) and explanation, p. 134 (*op. cit.*), be correct, then his handiwork with the chisel at the point of entry into the bone on the inner side, whether it be used as it advances as a lever to press sufficiently aside the sides of the severed internal parts of the bone, or aided by the mallet as a chipping instrument, which we know in Macewen's hands it is not, so as to leave almost only a linear space between the severed parts instead of the larger triangular space on the outside here represented, the femur must be proportionately shortened on the inside by such a process. If Macewen's explanation be applicable, it can only be in those cases of young children, whom he admits having operated on, in whom the bones were soft and compressible. In eburnated bones of rachitic subjects especially, which evince extraordinary and fatiguing resistance to the saw, and in adult bones

of normal hardness of atonic or idiopathic in-knee subjects, the bones will not permit the crushing aside by the chisel-osteotome. They are more disposed to split; and it seems to us probable that when the surgeon, after chiselling through two-thirds of the bone, or more, has straightened a limb without the production of the sound of the remainder having snapped apart, it has, in the hard *adult* or eburnated bone of the *rachitic subject*, resulted from its having been cracked by the chisel through the remainder of the distance to be severed, and thus the limb could be straightened without resistance, rather than that the yielding was due to bending in such cases. We consider that Dr. Macewen's section of the femur, made by him for sound reasons, from the inner aspect of the bone, leaves it, as regards the gap to be filled up, in nearly the same condition as if he divided it from the outer side.

In fig. 50 the disparity in length of the two condyles is greater than we remember to have ever actually seen, but this disparity in all cases of knock-knee is determined and gradually augmented by the gradually increasing inward inclination of the knee. In short, the changes in size and form of the internal condyle is not an original malformation, but one resulting from the action of gravity and of the muscles, the latter being the agents in some rare cases of fœtal origin.

We have been informed of a case in which a surgeon, whilst performing the supra-condylar operation, had the misfortune to split the femur longitudinally. This accident could never happen in the softened bone of the child; *ergo*, anyone unskilled in the use of the chisel should only attempt division in the young, because their bones are apt not to have become eburnated. We have, however, said sufficient in the former pages against the practice of performing osteotomy at all in young children, for one of the best of reasons that their bent knees and bones easily

permit straightening by gentle, painless, prompt, and safe mechanical means. Even in adolescents osteotomy is, in our opinion, unjustifiable, unless adequate skilful instrumentalism has been tried in vain.

The experience derived from the use of instrumental treatment and from osteotomy leads to the conclusion that the solidification of the bones of a rachitic subject, the beginning of which is very evident at about the age of five or seven years and marks the cessation of rachitic disease, differs materially in hardness and density from that perfect ivory hardness and full eburnation which characterises the bones of a rachitic adult, in which the labour of sawing a femur or tibia asunder is an arduous one. For the same reason chisel osteotomy in the adult is more difficult than in the growing child or adolescent. A firm grasp of the chisel-osteotome by the surgeon is necessary; at the same time his fingers need to feel every movement of the implement, as if they reached to its extremity so as to watch its slightest inclination to depart from the proper direction.

We go further, and say that no surgeon untrained in the manual use of such "tools" should undertake this operation. It is a piece of handiwork requiring dexterity such as many surgeons do not possess, however great may be their knowledge of surgical anatomy. Macewen, having done over 800 such osteotomies, has gone through a long apprenticeship in his benevolent career for the relief of the previously neglected population of a great manufacturing and commercial city.

We have shown (p. 16) that about the commencement of puberty, say from the age of ten or twelve to the fourteenth or sixteenth year, growth is extraordinarily rapid, and osteotomy has not been tested sufficiently long to enable us to judge of its effect upon the subsequent growth and length of the limb, particularly when performed near the epiphysis. Some may consider that this possible impairment of growth

is of less importance when both limbs are subjected to operation, or in the rachitic, who are predisposed by that disease to diminished growth. In non-rachitic in-knee, which occurs principally in those destined to be tall, or at the ages when growth is most rapid, anything calculated to interfere with growth of bone should, if practicable, be avoided.

The treatment of curvatures of the bones is so associated with in-knee deviation that we may detail in this place our experience and reflections on the best mode of relieving them, whether by mechanical or operative means. In the use of mechanical apparatus it is advisable to make direct pressure on the most prominent part, when from the nature and form of the curve it is attainable without the risk of injuring or abrading the integument. At the same time counter-pressure requires to be made, if possible, at the upper and lower ends of the bone.

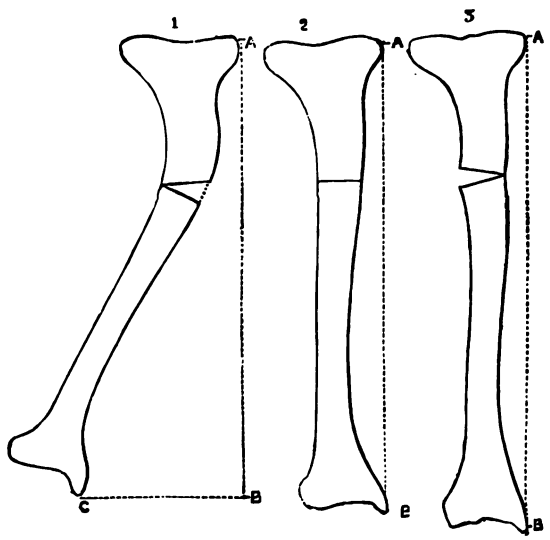
Thus, as an encouragement to the employment of well-directed mechanical apparatus,* we showed, in a former work, that the femur of an adolescent aged sixteen, which had been fractured nine months before, and had been suffered through the acknowledged neglect of the surgeon to unite at nearly a right angle, presenting forwards, with a corresponding great shortening of the member, had been rectified in a few months. We recommend in such a case double "iron" from the pelvis to the ground, with a crutch beneath the tuberosity of the ischium to receive much of the weight of the trunk during any permissible exercise. Direct pressure on the protruding angle should be made by a properly shaped padded metal piece, acting from before backwards. We trust mainly to the shape of the head of the femur and its connections with the acetabalum as the upper fulcrum, and upon a padded metal piece behind the condyles as the lower fulcrum.

As regards osteotomy for the relief of bone curvatures,

* Little: 'On Deformities of the Human Frame,' p. 40.

except in cases of extreme curvature, with such shortening of the parts on the concave side as to render straightening after simple division impossible, we regard simple division of the bones, at or about the centre of the curve, as far preferable to removal of a wedge. The operation itself is simpler in the former case, and less serious; the soft parts are less likely to be damaged, and no fragments or chips of bone liable to be left in the wound.

Fig. 52.




*Diagrammatic representation of* (1) *a curved tibia, with such a wedge as has often been removed for the purpose of straightening, marked out;* (2) *the same, with the wedge removed and the bone straightened;* (3) *the same, simply divided and straightened.*

The restoration of length in the limb is far greater in the case of simple division than in removal of a wedge, and the small gap left is quickly and surely filled up by new material, probably without greater effort of nature than when theoretically no gap exists. The accompanying diagram (fig. 52) shows the nature and amount of lengthening in a not excessively curved tibia. In the case of curvature of

only one limb, this restitution of equality in the length of the limbs is of some importance. Thus in 2, fig. 52, the line A B is increased 1·2 per cent.; in 3 it is increased 5·6 per cent. Suppose a tibia 14 inches long, curved as in the diagram, and in the case of simple division, the length of the limb would be increased 0·78 in., while in the case of wedge removal it would only be improved by 0·16 in.

It is right to say that the many surgeons who, notwithstanding that their particular methods of procedure have not prevailed, have had a share in advancing osteotomy step by step from the bold, yet coarse, sawing method, and large cutaneous incisions resorted to by Rhea Barton and Mayer, to the almost subcutaneous method employed by Mr. W. Adams, the more cutaneous method of the chisel introduced for knee ankylosis by Mr. Little, and the numerous cases of in-knee relieved by that method by Dr. Macewen, have conferred a great blessing upon humanity. The success of osteotomy has been in great measure due to the example of subcutaneous tenotomy set by Stromeyer; to the proofs afforded by Jules Guérin in his numerous and extensive operations on living animals, conducted for the purpose of proving the safety of applying similarly extensive subcutaneous operations to man; to the teaching of the bloodless method of operating of Esmarch; and last, not least, by the enforcement of the value of antiseptic measures by Lister.

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